PUBLIC UTILITIES COMMISSION
505 Van Ness Avenue
San Francisco CA 94102-3298

Southern California Gas Company
GAS (Corp ID 904)
Status of Advice Letter 6273G
As of April 10, 2024

Subject: Southern California Gas Company Reallocation of Funding for the 2023 Research Development and Demonstration Plan in Compliance with Ordering Paragraph 3 of Resolution G-3601.

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STATE OF CALIFORNIA **GAVIN NEWSOM,** *Governor*

PUBLIC UTILITIES COMMISSION
505 Van Ness Avenue
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To: Energy Company Filing Advice Letter

From: Energy Division PAL Coordinator

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March 4, 2024

Advice No. 6273-G
(U 904 G)

Public Utilities Commission of the State of California

Subject: Southern California Gas Company Reallocation of Funding for the 2023 Research Development and Demonstration Plan in Compliance with Ordering Paragraph 3 of Resolution G-3601.

Purpose

Southern California Gas Company (SoCalGas) hereby submits for approval with the California Public Utilities Commission (Commission) this Tier 2 Advice Letter (AL) as directed by Resolution (Res.) G-3601[1], Ordering Paragraph (OP) 3 to SoCalGas's AL 5991-G to record 2023 Research Development and Demonstration (RD&D) expenses to the Research, Development, and Demonstration Expense Account (RDDEA).[2]

Background

Public Utilities Code Section 740.1 provides for the Commission to authorize utility RD&D activities that have a reasonable probability of providing benefits to ratepayers through improved reliability and safety, environmental benefits, or operational efficiencies provided that achieving those benefits are reasonably probable and the focus is not unnecessarily duplicative of efforts by other research organizations. In Application (A.) 17-10-008, SoCalGas requested to continue its RD&D program for the 2019 GRC cycle, forecasted an average annual funding level of $14.329 million, and proposed to continue to record RD&D expenses in a one-way balancing account.[3]

[1] Res. G-3601 to Southern California Gas Company's Advice Letter 5991-G requesting to record Research, Development, and Demonstration (RD&D) expenses to its RD&D Account.
[2] Decision (D.)19-09-051 (2019 GRC Decision), addresses the Test Year (TY) 2019 General Rate Cases GRC) of San Diego Gas & Electric Company and SoCalGas.
[3] Application (A.)17-10-008, Application of Southern California Gas Company for Authority, Among Other Things, to Update its Gas Revenue Requirement and Base Rates Effective on January 1,

In the 2019 GRC Decision, the Commission found that SoCalGas's RD&D programs were both complementary and supplementary to other natural gas research and development programs[4] and authorized continuing the program through the TY 2019 GRC cycle at the average annual funding level requested by SoCalGas.[5] SoCalGas recognizes the importance of coordinating with the California Energy Commission (CEC) and other Investor Owned Utilities (IOU) to enhance the effectiveness of each individual RD&D program. To that end, SoCalGas is committed to increasing and formalizing coordination efforts with CEC and other California Gas IOUs that fund and conduct gas RD&D.

The 2019 GRC Decision required that prior to SoCalGas recording 2021 RD&D expenses to the RDDEA memorandum account, it should submit a Tier 3 Advice Letter and include a Research Plan for the following calendar year that would:

(1) detail budgets are broken down by research sub-program area,
(2) explain how the projects help improve reliability, safety, environmental benefits, or operational efficiencies, and
(3) discuss how SoCalGas incorporated feedback from workshop stakeholders and Commission staff.[6]

In addition to the requirements outlined in the 2019 GRC Decision, the Commission provided guidance in 2022 for future RD&D Research Plans in OP 5 of Resolution G-3586. The Commission recognized in Resolution G-3586 that SoCalGas's research project activity can span multiple years, with some project funding already contracted and spent as the subsequent year research plan is being considered.[7] Resolution G-3586 authorized SoCalGas to record in the one-way RDDEA balancing account expenses for multi-year projects approved and contracted prior to the Resolution.[8]

On June 15, 2022, in compliance with Res. G-3586, SoCalGas submitted its 2023 RD&D Research Plan through Advice Letter (AL) 5991-G. On January 1, 2023, SoCalGas ceased entering into new agreements for RD&D projects pending a Commission decision on AL 5991-G for the 2023 RD&D Research Plan. During 2023, SoCalGas continued its ongoing RD&D activities for multi-year programs previously approved under G-3586 including agreements entered into during Fiscal Year (FY) 2022 and prior.

On November 30, 2023, the Commission issued Resolution G-3601, which partially approved and modified SoCalGas's AL 5991-G to set the funding level for the 2023 RD&D Plan at $16,874,000 (OP 1) and a program administration budget capped at 10 percent of the total budget, or $1,687,400, for 2023, excluding the costs from new requirements such as Program Evaluation and comprehensive Gas Research, Development, and Demonstration database included in this Resolution (OP2). This Advice Letter was ordered by the

2019(October 6, 2017), Exhibit (Ex.) SCG-21 Direct Testimony of Lisa L. Alexander at LLA-9 - LLA-20.
[4] D.19-09-051 at 745-746 (Findings of Fact (FOF) 169-171).
[5] *Id.* at 381, 775 (OP 2).
[6] *Id.* at 379.
[7] *Id.* at 20.
[8] Res. G-3586 at 7.

Commission in (OP 3) to include the following: 1) a track-change version of its original Plan; 2) a clean version of its updated Plan; 3) a table describing the changes it has made aligned with the ordering paragraph and page number.

Furthermore, SoCalGas was ordered that this Advice Letter include the following modifications included in the applicable Ordering Paragraphs of G-3601:

OP3a. SoCalGas shall propose how it will reallocate $7,301,717 of its 2023 Gas RD&D funding, which was originally allocated to the following subprograms: Carbon Capture, Utilization, and Sequestration, Off-Road, Onboard Storage, On-Road, Refueling Stations, Distributed Generation, Industrial Process Heat, and Residential Appliances. SoCalGas shall also reallocate any funding allocated toward hydrogen blending research in the System Design & Materials subprogram. SoCalGas may restore the relevant portion of the $7,301,717 subprogram funds as allowed by modifications to the Resolution as described above. In its Tier 2 AL, SoCalGas shall provide granular budget information for each subprogram delineating the restored funding from the funds which must be reallocated. For the reallocation, SoCalGas shall propose projects that comply with the RD&D criteria described herein and specifically consider reallocating these funds toward gas pipeline and system integrity, gas system decommissioning, and cybersecurity. SoCalGas shall reallocate $129,938 of these 2023 Gas RD&D funds toward its proportional share of a comprehensive Gas RD&D database. SoCalGas shall also reallocate $675,000 of these 2023 Gas RD&D funds toward a comprehensive program evaluation.

OP3b. SoCalGas shall demonstrate that any hydrogen programs and projects conducted by SoCalGas utilize clean renewable hydrogen, consistent with the definition given in Decision (D.) 22-12-057. We deny any hydrogen projects/programs that are not consistent with this definition of clean renewable hydrogen. SoCalGas shall update its Plan in its Tier 2 AL demonstrating that it will use the allowed clean renewable hydrogen or otherwise propose to reallocate funds.

OP3c. SoCalGas shall demonstrate that the System Inspection & Monitoring clean renewable hydrogen blending projects do not duplicate the hydrogen blending pilots conducted through D.22-12-057.

OP3d. SoCalGas shall provide greater detail about how its proposed projects and strategies specifically will benefit the ESJ communities that fund this research related to the state’s climate goals. Further, SoCalGas shall explain how it measures the impacts of its research on ESJ communities.

OP3e. SoCalGas shall provide an interim update on its impact (benefit) analysis framework as ordered in Resolution G-3586, but complete development of its final framework as guided by the outcome of the Uniform Impact Analysis Framework guidance in R.19-10-005.

OP3f. SoCalGas shall explicitly justify how its 2023 Gas RD&D consortia dues directly benefit its gas ratepayers or SoCalGas must otherwise reallocate these funds informed by the guidance in this resolution.

OP4. Southern California Gas Company (SoCalGas) shall allocate 4% ($675,000) of its 2023 Gas Research, Development, and Demonstration (RD&D) funds to fund a comprehensive evaluation of SoCalGas’s Gas RD&D program to be implemented by Energy Division. Energy Division staff shall develop a scope of work, issue a request for proposal, and hire and manage the contractor. Staff may create efficiencies by utilizing a fiscal manager and evaluating all Gas RD&D administrators through a comprehensive evaluation process.

OP7. Southern California Gas Company may spend its approved 2023 Research, Development, and Demonstration funding in calendar year 2024.

OP8. Southern California Gas Company (SoCalGas) is authorized to continue projects that are currently ongoing in its Distributed Generation and Industrial Process subprograms. Any new Research, Development, and Demonstration projects in these subprograms shall not be funded by SoCalGas.

OP9. Southern California Gas Company (SoCalGas) Advice Letter 5991-G proposing for SoCalGas to record up to $16.874 million in Research, Development, and Demonstration (RD&D) expenses is partially approved.

Attachments of Proposed Revisions to RD&D 2023 Research Plan

In compliance with OP 3, SoCalGas proposes to modify its 2023 RD&D Research Plan and budgets to comply with Res. G-3601 and describes the proposed changes in the attachments to this Advice Letter:

Attachment A. Clean version – SoCalGas Research, Development and Demonstration Program REVISED 2023 Research Plan.

Attachment B. Track-change version – SoCalGas Research, Development and Demonstration Program REVISED 2023 Research Plan.

Attachment C. Table describing proposed changes – RD&D 2023 Research Plan Revisions Roadmap.

In addition to the attachments directed above, SoCalGas includes clean and track-change versions of Appendix E for consistency:

Attachment D. Clean version of Appendix E – SoCalGas Research, Development and Demonstration Program Project Details REVISED 2023 Research Plan

Attachment E. Track-change version of Appendix E – SoCalGas Research, Development and Demonstration Program Project Details - REVISED 2023 Research Plan

Proposed Reallocation of 2023 RD&D Research Plan Funding

In compliance with OP 3a, the following sections detail how SoCalGas proposes to (1) reallocate $7,301,717 of its 2023 Gas RD&D funding, which was originally allocated to Carbon Capture, Utilization, and Sequestration, Off-Road, Onboard Storage, On-Road, Refueling Stations, Distributed Generation, Industrial Process Heat, and Residential Appliances (2) reallocate any funding allocated toward hydrogen blending research in the System Design & Materials subprogram (3) restore the relevant portion of subprogram funds as allowed by modifications to the Resolution and (4) provide budget information for each subprogram delineating the restored funding from the funds which must be reallocated (5) reallocate projects that comply with the RD&D criteria and specifically considered reallocating these funds toward gas pipeline and system integrity, gas system decommissioning, and cybersecurity and (6) allocate funds toward its proportional share of a comprehensive Gas RD&D database and toward a comprehensive program evaluation.

Summary of Funding Allocation Proposal

In Table A, SoCalGas provides a high-level reallocation of the $7,301,717 in funds originally budgeted to the Carbon Capture, Utilization, and Sequestration, Off-Road, Onboard Storage, On-Road, Refueling Stations, Distributed Generation, Industrial Process Heat, and Residential Appliances to authorized subprograms. Details of each line item from the funding reallocation can be found in the subsequent tables and sections.

Table A: Summary of Proposed Funding Reallocation

2023 RD&D Research Plan Funding Reallocation	**Cost $**
Funding Allocation Designated by Res. G-3601[(a)]	1,719,500
Retired Subprograms - Cost Incurred Prior to Issuance of Res. G-3601[(b)]	2,399,904
Funds Available for Reallocation Considering Res. G-3601 Modifications[(c)]	3,182,313
Total 2023 Budget from Retired Programs	**7,301,717**

a. Refer to Table B for detailed breakout.
b. Refer to Table C for detailed breakout.
c. Refer to Table D for detailed breakout.

Funding Allocation Designated by Resolution G-3601

In compliance with OP 3a, SoCalGas reallocated funds to its proportional share of a comprehensive Gas RD&D Database and a comprehensive program evaluation, OP 4. Additionally, OP 8 authorized restoration and continuation of currently in-progress projects in the Distributed Generation and Industrial Process Heat subprograms.[9] The designated funding reallocation is detailed in Table B below.

Table B: Funding Allocation Designated by Res. G-3601

Funding Allocation	**Res. G-3601 Modification**	**Cost $**
Restored Funding (OP 8)	Distributed Generation	321,334
Restored Funding (OP 8)	Industrial Process Heat	593,228
Directive (OP 3a)	Comprehensive Gas RD&D database	129,938
Directive (OP 3a/OP4)	Comprehensive RD&D program evaluation	675,000
Total Funding Allocation Designated by Res. G-3601		**1,719,500**

[9] All new Distributed Generation and Industrial Process Heat projects not covered by the restoration have been retired per Res. G-3601 and retired funding in these subprograms is reflected in Table D.

Retired Subprograms – Cost Incurred Prior to Issuance of Resolution G-3601

SoCalGas is in the process of terminating contracts for the disallowed subprograms pursuant to the directives of Res. G-3601. Importantly, these contracts are comprised of ongoing, multi-year contracts that were previously approved by the Commission in Res. G-3586, and as such were ongoing and active during 2023 before the issuance of Res. G-3601. The nature and existence of multi-year projects in the context of the RD&D program were previously contemplated when the Commission approved the 2022 RD&D Research Plan in Res. G-3586. Relying on this previous approval, SoCalGas incurred ongoing costs related to previously approved projects that were active during 2023 while awaiting a disposition on AL 5991-G (submitted June 15, 2022) up to the issuance of Res. G-3601 (issued November 30, 2023).

The costs detailed in Table C below were incurred from January to November 30, 2023, and are proposed to be allocated to their respective retired subprograms to recover costs associated with ongoing, pre-approved activities that took place before the issuance of Res. G-3601. SoCalGas submits that this treatment is consistent with the precedent set by the Commission in the Senate Bill (SB) 1371 Bi-annual Leak Abatement proceeding. In that case, the Commission authorized recovery of costs SoCalGas recorded, in good faith and pursuant to preliminary guidance from Safety Enforcement Division (SED), while awaiting final resolution from the Commission.

There are costs incurred in previously approved multi-year contracts during January to November 30, 2023, that have already been paid before the issuance of Res. G-3601 and these amounts are reflected in the “Actual Incurred Cost” column of Table C. In addition, there are costs which SoCalGas has identified as “Estimated Incurred Cost” column of Table C which represents a combination of confirmed and estimated costs that have been or will be invoiced based on expected project progress against milestones and/or services rendered up to November 30, 2023. SoCalGas shall direct their partners to clearly provide the costs incurred up to November 30, 2023, only, when submitting their invoices for the purposes of establishing such costs. If the estimates are greater than the invoices received from partners, SoCalGas proposes to reallocate the difference between these two amounts towards approved subprogram research areas. If the estimates are less than the amounts invoiced, SoCalGas proposes to seek the difference between these two amounts in a subsequent Research Plan Advice Letter submission.

Table C: 2023 Retired Subprograms - Costs Incurred Before Issuance of Res. G-3601

Program	Retired Subprogram	Actual Incurred Cost $ (Jan-Nov ‘23)	Estimated Incurred Cost $ (Jan-Nov ‘23)	Total Project Cost $ (Jan-Nov ‘23)
Low Carbon Resources	CCUS	816,567	28,986	845,553
Clean Transportation	Off-Road	21,036	175,000	196,036
	Onboard Storage	0	0	0
	On-Road	556,841	200,000	756,841
	Refueling Stations	118,263	63,439	181,702

Clean Generation	Distributed Generation[(d)]	0	0	0
Customer End-Use Applications	Industrial Process Heat[(e)]	0	0	0
	Residential Appliances	177,022	242,750	419,772
Total Cost Incurred Prior to Issuance of G-3601		**1,689,729**	**710,175**	**2,399,904**

[d.] Cost for these subprograms are included as restored funding in Table B.
[e.] Id.

Funds Available for Reallocation Considering Res. G-3601 Modifications

In compliance with OP 3a, SoCalGas provides detailed budget information in Table D for each subprogram that has been retired per Res. G-3601, including the funds available for reallocation.[10] Table D below details the specific subprograms where such funds are proposed to be reallocated from.

Table D: Retired Subprogram Funding Available for Reallocation

Retired Subprograms	**Disallowed Funding per Res. G-3601**	**Actual Cost $ (Jan-Nov '23)**	**Estimated Incurred Cost $ (Jan-Nov '23)**	**Funds Available for Reallocation**
CCUS	2,809,521	(816,567)	(28,986)	**1,963,968**
Off-Road	637,837	(21,036)	(175,000)	**441,801**
Onboard Storage	425,225	0	0	**425,225**
On-Road	637,837	(556,841)	(200,000)	**(119,004)**
Refueling Stations	425,225	(118,263)	(63,439)	**243,523**
Distributed Generation[(f)]	835,263	0	0	**835,263**
Industrial Process Heat[(g)]	850,450	0	0	**850,450**
Residential Appliances	680,359	(177,022)	(242,750)	**260,587**
Allocation Designated by G-3601[(h)]	-	-	-	**(1,719,500)**
Totals	7,301,717	(1,689,729)	(710,175)	**3,182,313**

[f.] See details in Table B above.
[g.] Id.
[h.] Id.

Proposed Subprogram Funding Reallocation to Approved Funding Areas

In compliance with OP 3a, SoCalGas provides the proposed reallocation of funding to projects that comply with the RD&D criteria outlined in G-3601. This proposal reflects SoCalGas's consideration of the Commission's directives in assessing appropriate research areas for the 2023 Research Plan and specifically reallocating these funds toward gas pipeline and system integrity, gas system decommissioning, and cybersecurity where possible. Table E provides the proposed reallocation to authorized subprograms.

[10] See Table 5 of the Revised 2023 RD&D Research Plan.

Table E: Reallocation of Available Funding to Approved Subprograms

Reallocated Subprograms	Reallocated Funds $
Renewable Gas Production	1,122,084
Environmental & Safety[i]	250,000
Operations Technology[j]	250,000
System Design & Materials[k]	250,000
Integration & Controls[l]	905,144
Advanced Innovation	100,059
Commercial Applications	250,146
Commercial Food Service	54,880
Total Reallocated Funds to Authorized Subprograms	**3,182,313**

[i] Indicates funds that have been reallocated to potential gas system decommissioning research efforts.

[j] Indicates funds that have been reallocated to potential cybersecurity research efforts.

[k] Indicates funds that have been reallocated to potential gas system integrity research efforts.

[l] Indicates a portion of funds has been reallocated to potential cybersecurity research efforts ($250k).

Closeout Costs Associated with Final Deliverables for Fully Paid Previously Approved Multiyear Projects and Contract Terminations of Previously Approved Multi-year Projects in Subprograms Retired Pursuant to Res. G-3601

SoCalGas will terminate the contracts for projects in subprograms that are being retired consistent with the denial of certain subprograms in. Res. G-3601. SoCalGas anticipates that there may be an unknown amount of incremental costs and/or a return of unspent funds directly related to the contract termination of the previously approved multi-year projects. SoCalGas proposes to offset project costs with any unspent funds for that project. For any remaining net outstanding project costs, SoCalGas proposes to recover these closeout costs in a subsequent Research Plan Advice Letter submission. To the extent that funds recovered are greater than project closeout costs, SoCalGas proposes to reallocate these funds to approved subprogram areas in FY 2024.

SoCalGas also notes that seven of the previously approved multiyear projects in the retired CCUS and On-Road subprograms have been fully funded prior to November 30, 2023. There remain final milestones and deliverables for these projects to reach completion, such as the issuance of the final report. If these projects were otherwise terminated now, the potential benefits and learning would not be fully realized by ratepayers. SoCalGas proposes to complete these projects and expects there will be incremental, *de minimis*, close out costs, such as costs to analyze, review, report, and share the project results. For any costs incurred to close out these projects, SoCalGas proposes to allocate them within the Program Administration Budget in the next Research Plan Advice Letter submission.

Proposed Reallocation of Any Funding Allocated Toward Hydrogen Blending Research and Differentiation of System Inspection & Monitoring Clean Renewable Hydrogen Blending Projects

In compliance with OP 3a, SoCalGas was ordered to reallocate any funding allocated toward hydrogen blending research in the System Design & Materials subprogram.

SoCalGas RD&D has three hydrogen blending projects under the System Design and Materials subprogram that were ongoing, multi-year contracts with completion dates in 2024. As described above, these active projects had incurred costs during 2023, prior to the issuance of G-3601. At the time G-3601 was issued, the costs for the three projects had been fully incurred. Pursuant to the directives of Resolution G-3586 that authorized recovery of funds spent on ongoing projects in previously approved subprograms, SoCalGas is proposing to report completion of these projects in the 2024 RD&D Annual Report, including results and ratepayer benefits realized. Accordingly, no additional funds remain that may be proposed for reallocation to other project areas.[11]

Further in compliance with OP 3c, Res. G-3601 directs SoCalGas to demonstrate that the System Inspection & Monitoring hydrogen blending projects are not duplicative of the hydrogen blending pilots conducted through D.22-12-057. SoCalGas notes generally that research that may seem duplicative in nature at a high level can be differentiated when assessing the details and scope of the work. Specifically, the System Inspection & Monitoring subprogram has two active hydrogen blend projects.[12] The first is looking at the potential impact of introducing hydrogen into underground storage, which is out of the scope of the pilot projects. The second is a Pipeline and Hazardous Materials Safety Administration (PHMSA) project that aims at determining the impact of hydrogen injection on leakage dynamics, and the effect of hydrogen on existing natural gas leak detection equipment. The resulting analysis will inform new approaches for hydrogen sensing and integration into next-generation leak detection equipment and influence PHMSA federal code and regulation regarding acceptable technologies for monitoring and surveying systems with hydrogen and hydrogen-natural blends. The results of this project can provide guidance for leak detection technologies and protocols that could be adopted by the pilots. Accordingly, these activities enhance and complement rather than duplicate anticipated work in the pilots.

SoCalGas RD&D projects are also differentiated from the hydrogen blending pilots by other factors including testing methodologies, operational area of focus, and technology readiness level. When earlier-stage research and testing is conducted prior to pilot projects to obtain a robust dataset or to address data anomalies such projects should be viewed as supplemental and/or complementary rather than duplicative of related pilot projects. More details on the projects are provided in Attachment D – Project Details in Column V: Hydrogen Blend Projects.

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[11] These projects are designated in Appendix E of the revised 2023 RD&D Research Plan under “Hydrogen Blending Projects” column V.

[12] Attachment D – Project Details: No. GO124 Underground Natural Gas Storage and Risk of Corrosion/Souring (7.22.i) and No. GO90 Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends (7.23.f).

Specific Consideration of Reallocating Funds Towards Gas Pipeline and System Integrity, Gas System Decommissioning, and Cybersecurity

In compliance with OP 3a, SoCalGas appreciates the Commission's clear directive to consider reallocation of funds in retired subprograms to drive research in the areas of gas pipeline and systems integrity, gas system decommissioning, and cybersecurity. In light of that directive and in alignment with RD&D's current research attributes and capabilities, SoCalGas proposes to redirect funds from retired subprograms to such research areas.[13] In particular, SoCalGas proposes reallocating $250,000 to pipeline and systems integrity projects under the System Design and Materials subprogram, $250,000 to research efforts involving gas system decommissioning in the Environmental and Safety sub-program, $250,000 to research efforts involving cybersecurity projects in the Operations Technology subprogram, and $250,000 to cybersecurity research projects under the Integration and Controls subprogram. More detailed information about funding reallocation is presented in Section 6 of the revised 2023 RD&D Research Plan.

Proposal to Demonstrate that Hydrogen Programs and Projects Conducted by SoCalGas use Clean Renewable Hydrogen as Defined in Decision (D.) 22-12-057

In compliance with OP 3c, SoCalGas remains committed with the State's clean renewable hydrogen (CRH) vision and supports the overall direction the Commission is taking in G-3601 regarding the utilization of CRH in SoCalGas's research projects. SoCalGas understands that requiring CRH be used in hydrogen gas research and development approved by the Commission to be a novel requirement. Therefore, for active research projects that utilize hydrogen, SoCalGas will review the sources of gases used for each one to determine if the source complies with the definition of CRH. If it is concluded the hydrogen used does not fit the definition of CRH, SoCalGas will evaluate the feasibility of procuring CRH for the project at the volumes required. For projects where no options are feasible, next steps may include termination of contracts and reallocation of funds to an approved subprogram or suspension of contracts until an alternative solution is identified. As part of this evaluation, SoCalGas plans to share the findings, including market participants, quantities available to purchase, source and location of CRH, price, carbon intensity, purity, certification process, and estimated transportation costs, with Energy Division. These findings will help SoCalGas, the Energy Division, and research partners better understand the market for CRH, including the commercial arrangements needed to both procure CRH to comply with this requirement.

Details About How Proposed Projects and Strategies will Benefit the ESJ Communities that Fund this Research Related to the State's Climate Goals and Related Measurement

A description of benefits to ESJ communities provided by research in each subprogram, as well as equity considerations, can be found in the Equity Considerations section for each program or subprogram in the revised 2023 Research Plan. As detailed below, SoCalGas has implemented process changes to better define and improve benefits to ESJ communities

[13] See Table E above.

in the project selection process. Furthermore, SoCalGas is following the EPIC program work to develop a UIAF to properly measure project benefits to ESJ communities. As projects are created, executed, and finalized, ESJ benefits will be defined, reported, and quantified under these new processes.

OP 3d Current Efforts to Measure the Benefits to Ratepayers with a Focus on Equity

In August 2023, SoCalGas issued an updated version of its Equity Engagement Roadmap, or EER. The EER identified three themes and six specific tasks to guide RD&D's ongoing engagement efforts and to develop, update, and track equity engagement metrics that SoCalGas leadership, the CPUC, and the public can use to evaluate the degree to which the projects supported by SoCalGas RD&D address inequities related to climate, income, and race/ethnicity, age, and other diversity dimensions in the communities served by SoCalGas.

Task 1 of the EER guides RD&D to "Monitor and report key RD&D Equity Engagement project metrics in the RD&D Annual Report." As part of this task, the 2022 RD&D Annual Report[14] (and the Spanish version, "2022 Informe Annual"[15]) include a map of RD&D projects located in ESJ Communities. In 2022, 61 RD&D projects were located in ESJ Communities.

Furthermore, Task 6 of the EER guides RD&D to "review/revise RD&D project policies to include DEI components." As part of this task, RD&D updated its project evaluation process to include "Equity Component" field in the project description as well as to add "Equity Consideration" to the list of project evaluation criteria. These additions are designed to encourage RD&D and the research project teams to consider adding components to project scopes to consider environmental justice communities, enhance community engagement, and improve diversity of research teams. Some specific examples of these equity-focused additions can be found in Section 4.4 of Attachment A. SoCalGas is committed to sharing this additional information with the Commission, Energy Division, the research community, other stakeholders, and the public, as projects are developed and proceed through the project lifecycle.

Further Efforts to Address and Assess ESJ Benefits from RD&D Projects

As a result of the directives in G-3601, SoCalGas proposes to conduct a series of studies, in coordination with Energy Division staff and the ESJ Advisory Panel (curated by ED pursuant to OP 6g), to better continue to build upon understanding the needs of ESJ communities. The data will be used to inform a plan to address the key needs of ESJs. SoCalGas will use the study results to further inform the Uniform Impact Analysis Framework (UIAF) (pursuant to OP 3e) to include an analysis of benefits specifically for ESJ communities.

[14] 2022_SoCalGas_RDD_Annual_Report.pdf.
[15] 2022_SoCalGas_RDD_Informe_Anual.pdf.

Update on its Impact (Benefit) Analysis Framework as Ordered in Resolution G-3586

In compliance with OP 3e, on July 29, 2022, SoCalGas submitted AL 6014-G, which created the foundational principles for a Benefits Analysis Framework. AL 6014-G was approved by the CPUC on August 28, 2022. In D.23-04-042, issued April 28, 2023, the Commission found that the term "benefits analysis framework" should be now called the "uniform impacts framework", further explaining that "research and development projects have an element of risk, which means that not all EPIC projects will directly benefit ratepayers in a quantifiable manner." SoCalGas RD&D proposes to make ongoing improvements to the UIAF, adapting as informed by the process and outcomes of proceeding R.19-10-005, participating in upcoming EPIC workshops, and continuing to work in consultation with Energy Division staff as directed in Res. G-3586.

Consortia Dues Directly Benefit its Gas Ratepayers

In compliance with OP 3f, the majority of SoCalGas RD&D consortiums cost is directly allocated to collaborative Research and Development projects that are either initiated by or specifically selected for funding by SoCalGas. Therefore, the majority of this funding is directly invested into research that is relevant for SoCalGas ratepayers. These projects leverage significant funding from other consortium members, thus reducing cost burden of research on ratepayers. This is further demonstrated in Section 6.2 of Attachment A, which provides a detailed breakdown of the consortium membership dues related to SoCalGas's RD&D program. In addition, summaries of four successful research consortium projects and their ratepayer benefits are provided. Figure 1-1 in Attachment A demonstrates that the co-benefits of safety and reliability are realized by the majority of projects within each consortium. Since projects can align with more than one benefit the remaining ratepayer co-benefits: operational efficiency, improved affordability, reduced GHG emissions, and improved air quality are also represented.

The subcategory of funds allocated to administrative expenses also have direct benefits to SoCalGas ratepayers. For example, participation in the research consortiums facilitates collaboration and knowledge sharing between subject matter experts from other natural gas system operators, industry RD&D programs, academia, national laboratories, and other research organizations. Research consortiums generally provide members the opportunity to learn about and discuss emerging operational issues and needs within the industry, both nationally and internationally, including knowledge sharing of pipeline incidents, causes or insights on interactive threats which SoCalGas may otherwise have not been aware of (as they may have very low probability of occurrence but a high consequence). Consortium memberships also provide access to well-maintained libraries of relevant information to gas system operations. This knowledge results in safety and reliability benefits to SoCalGas ratepayer. In addition, consortium involvement helps raise SoCalGas's awareness of other research, so we can leverage those findings and identify non-redundant research gaps, maximizing ratepayer dollars towards more pressing and unaddressed issues.

Consortia memberships also provides access to solicitations for federal and state funding opportunities, as well as resources to apply and manage large national and state research projects. By positioning SoCalGas RD&D to better leverage federal and state funds, consortium participation can help reduce cost burdens on ratepayers for essential research. Therefore, RD&D's participation in these consortiums provide knowledge sharing functions and collaborations with partners in the gas industry including other utilities that have an impact on lessons learned for safe and reliable gas system operations benefitting our customers.

Protests

Anyone may protest this Advice Letter to the Commission. The protest must state the grounds upon which it is based, including such items as financial and service impact, and should be submitted expeditiously. The protest must be submitted electronically and must be received within 20 days after the date of this Advice Letter, which is March 24, 2024. Protests should be submitted to the attention of the Energy Division Tariff Unit at:

E-mail: EDTariffUnit@cpuc.ca.gov

In addition, protests and all other correspondence regarding this Advice Letter should also be sent electronically to the attention of:

Attn: Gary Lenart
Regulatory Tariff Manager
E-mail: GLenart@socalgas.com
E-mail: Tariffs@socalgas.com

Effective Date

SoCalGas asserts this submittal is subject to Energy Division disposition and should be classified as Tier 2 (effective after staff approval) pursuant to General Order (GO) 96-B. SoCalGas respectfully requests that this submittal become effective April 03, 2024, which is 30 calendar days after the date submitted.

Notice

A copy of this Advice Letter is being sent to SoCalGas' General Order (GO) 96-B service list and the Commission's service list in A.17-10-007, A.17-10-008, A.22-05-015, A.22-05-016, R.19-10-005, R.20-01-007, R.19-01-011, and R.13-11-005. Address change requests to the GO 96-B service list should be directed via e-mail to Tariffs@socalgas.com or call 213-244-2424. For changes to all other service lists, please contact the Commission's Process Office at 415-703-2021 or via e-mail at Process_office@cpuc.ca.gov.

By: /s/ Joseph Mock
Joseph Mock
Director – Regulatory Affairs

Attachments in accordance with Ordering Paragraph 03:

Attachment A.	Clean version – SoCalGas Research, Development and Demonstration Program REVISED 2023 Research Plan.
Attachment B.	Track-change version – SoCalGas Research, Development and Demonstration Program REVISED 2023 Research Plan.
Attachment C.	Table describing proposed changes – RD&D 2023 Research Plan Revisions Roadmap.
Attachment D.	Clean version of Appendix E – SoCalGas Research, Development and Demonstration Program Project Details REVISED 2023 Research Plan
Attachment E.	Track-change version of Appendix E – SoCalGas Research, Development and Demonstration Program Project Details - REVISED 2023 Research Plan

ADVICE LETTER SUMMARY

ENERGY UTILITY

MUST BE COMPLETED BY UTILITY (Attach additional pages as needed)

Company name/CPUC Utility No.:

Utility type:

☐ ELC ☐ GAS ☐ WATER

☐ PLC ☐ HEAT

Contact Person:
Phone #:
E-mail:
E-mail Disposition Notice to:

EXPLANATION OF UTILITY TYPE

ELC = Electric	GAS = Gas	WATER = Water
PLC = Pipeline	HEAT = Heat	

(Date Submitted / Received Stamp by CPUC)

Advice Letter (AL) #: Tier Designation:

Subject of AL:

Keywords (choose from CPUC listing):

AL Type: ☐ Monthly ☐ Quarterly ☐ Annual ☐ One-Time ☐ Other:

If AL submitted in compliance with a Commission order, indicate relevant Decision/Resolution #:

Does AL replace a withdrawn or rejected AL? If so, identify the prior AL:

Summarize differences between the AL and the prior withdrawn or rejected AL:

Confidential treatment requested? ☐ Yes ☐ No

If yes, specification of confidential information:
Confidential information will be made available to appropriate parties who execute a nondisclosure agreement. Name and contact information to request nondisclosure agreement/ access to confidential information:

Resolution required? ☐ Yes ☐ No

Requested effective date: No. of tariff sheets:

Estimated system annual revenue effect (%):

Estimated system average rate effect (%):

When rates are affected by AL, include attachment in AL showing average rate effects on customer classes (residential, small commercial, large C/I, agricultural, lighting).

Tariff schedules affected:

Service affected and changes proposed[1]:

Pending advice letters that revise the same tariff sheets:

[1] Discuss in AL if more space is needed.

Protests and all other correspondence regarding this AL are due no later than 20 days after the date of this submittal, unless otherwise authorized by the Commission, and shall be sent to:

CPUC, Energy Division Attention: Tariff Unit 505 Van Ness Avenue San Francisco, CA 94102 Email: EDTariffUnit@cpuc.ca.gov	Name: Title: Utility Name: Address: City: State: Zip: Telephone (xxx) xxx-xxxx: Facsimile (xxx) xxx-xxxx: Email:
	Name: Title: Utility Name: Address: City: State: Zip: Telephone (xxx) xxx-xxxx: Facsimile (xxx) xxx-xxxx: Email:

ATTACHMENT A

Advice No. 6273-G

Clean version – SoCalGas Research, Development and Demonstration Program REVISED 2023 Research Plan

SoCalGas

RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAM

REVISED 2023 RESEARCH PLAN

ORIGINAL SUBMISSION: JUNE 15, 2022
REVISED SUBMISSION: MARCH 3, 2024

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“The future is very bright. Humanity has important problems to solve but we are better positioned to solve them than at any other time in history. To help build a decarbonized energy system for California, SoCalGas is overcoming challenges, implementing solutions, and collaborating with innovative partners so every Californian can have access to clean, reliable, and affordable energy.”

—**Maryam Brown**
President
SoCalGas

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TABLE OF CONTENTS

ACRONYMS

Acronym	Description
AB	Assembly Bill
AI	Artificial Intelligence
ARPA-E	Advanced Research Projects Agency-Energy
BETO	Bioenergy Technologies Office
BTU	British Thermal Unit
CARB	California Air Resources Board
CAV	Connected and Autonomous Vehicle
CBO	Community-based Organizations
CCS	Carbon Capture and Sequestration
CCST	California Council on Science and Technology
CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Utilization, and Sequestration
CEC	California Energy Commission
CFR	Code of Federal Regulations
CFS	Commercial Food Service
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CNTP	Catalytic Non-Thermal Plasma
CO_2	Carbon Dioxide
CPUC	California Public Utilities Commission
CRH	Clean Renewable Hydrogen
CSP	Concentrated Solar Power
CSU	California State University
CTP	Clean Transportation Program
DAC	Disadvantaged Community
DBE	Diverse Business Enterprise
DG	Distributed Generation
DME	Dimethyl Ether
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EERE	Energy Efficiency and Renewable Energy
EMAT	Electromagnetic Acoustic Transducer
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPIC	Electric Program Investment Charge
ESJ	Environmental and Social Justice
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FCTO	Fuel Cell Technologies Office
GHG	Greenhouse Gas

GRC	General Rate Case
GTI	GTI Energy (formerly Gas Technology Institute)
HFCV	Hydrogen Fuel Cell Vehicle
IoT	Internet of Things
IOU	Investor-Owned Utility
IPCC	Intergovernmental Panel on Climate Change
LCFS	Low Carbon Fuel Standard
LIC	Low-Income Community
MHD	Medium- and Heavy-Duty
MSS	Mobile and Stationary Source
NAACP	National Association for the Advancement of Colored People
NDE	Nondestructive Examination
NETL	National Energy Technology Laboratory
NGA	Northeast Gas Association
NGRP	Natural Gas Research Program
NGV	Natural Gas Vehicle
NREL	National Renewable Energy Laboratory
OIR	Order Instituting Rulemaking
OTD	Operations Technology Development
PE	Polyethylene
PM	Particulate Matter
PNNL	Pacific Northwest National Laboratory
PRCI	Pipeline Research Council International
PSPS	Public Safety Power Shutoff
R&D	Research and Development
RD&D Program	SoCalGas' Research, Development, and Demonstration Program
RNG	Renewable Natural Gas
RPA	Regional Public Affairs
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
SCF	Standard Cubic Foot
SJVAPCD	San Joaquin Valley Air Pollution Control District
SME	Subject Matter Expert
SMP	Sustaining Membership Program
SMR	Steam Methane Reforming
SoCalGas	Southern California Gas Company
SOFCS	Solid Oxide Fuel Cells
T&D	Transmission and Distribution
TAP	Technology Advancement Program
TCO	Total Cost of Ownership
TRL	Technology Readiness Level
UIAF	Uniform Impact Analysis Framework

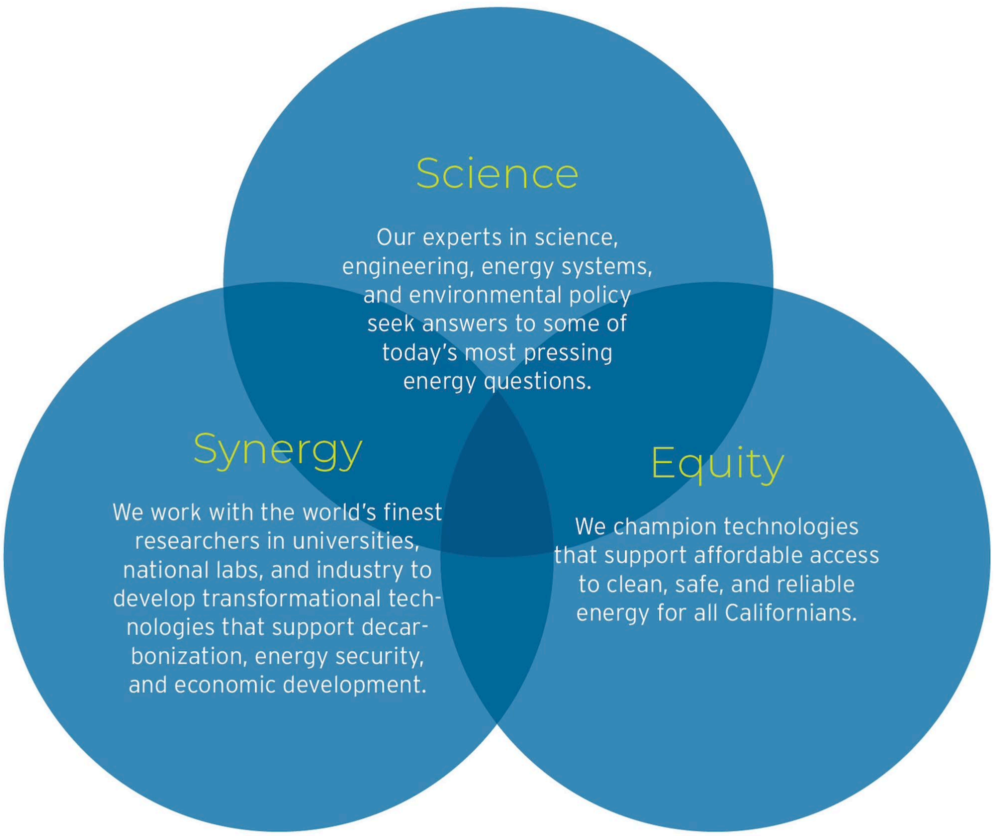
UC	University of California
UTD	Utilization Technology Development
VOC	Volatile Organic Compound
ZEV	Zero-Emission Vehicle

1 Overview

SoCalGas Research, Development, and Demonstration (RD&D) plays a key role in the company's efforts to achieve net zero greenhouse gas (GHG) emissions in its operations and delivery of energy by 2045. In collaboration with professionals from the world's top institutions, RD&D staff develop and demonstrate transformational products and technologies that promote decarbonization across the natural gas value chain and a diversified portfolio of clean, reliable, safe, and affordable energy sources.

Table 1: The vision, mission, and values of the RD&D Program align with the SoCalGas mission to build the cleanest, safest, and most innovative energy company in America.

VISION	MISSION
Advancing innovative technologies for safer, cleaner, and more reliable energy.	Identify transformational energy solutions. Build them. Share them with the world.
VALUES	



SoCalGas RD&D is staffed with subject matter experts (SME) in science, engineering, industrial process technology, and environmental policy. Every year, RD&D staff support hundreds of projects along the commercialization pathway—from lab-scale research and development (R&D) to multi-year precommercial demonstrations—with the ultimate goals of saving energy, reducing GHG emissions, improving air quality, and increasing the safety, reliability, and affordability of energy.

In 2021, SoCalGas RD&D provided technical assistance, outreach, strategic guidance, and almost $17 million in funding to 379 projects throughout California and around the nation. In 2023, RD&D Program staff anticipated spending a total of $16,874,000 supporting hundreds of projects. Modifications to this Revised Plan are detailed below in accordance with the issuance of California Public Utilities Commission (CPUC) Resolution (Res.) G-3601.

1.0 Revised RD&D 2023 Research Plan Pursuant to Res. G-3601

1.0.1 Background and Summary

SoCalGas RD&D submitted its initial 2023 RD&D Research Plan to the CPUC in Advice Letter (AL) 5991-G on June 15, 2022,[1] based on and consistent with the direction provided in Res. G-3586. In its initial submission, SoCalGas proposed to record up to $16.874 million to its RD&D Expense Account, describing how it would allocate RD&D funds into its seventeen subprograms and program administration.

On November 30, 2023, the CPUC issued Res. G-3601 approving, in part, the funding allocation proposed by SoCalGas in AL 5991-G. In Res. G-3601, the CPUC directed SoCalGas to modify the 2023 RD&D Research Plan and submit a revised proposal for reallocating denied funding allocations through a Tier 2 Advice Letter. Pursuant to these directives, the primary modifications included in the revised 2023 RD&D Research Plan are:

- Retirement of eight subprograms: Carbon Capture, Utilization, and Sequestration, Off-Road, Onboard Storage, On-Road, Refueling Stations, Distributed Generation, Industrial Process Heat, and Residential Appliances. Funds initially allocated under these subprograms are proposed to be reallocated to other subprograms including those approved and directed for consideration by Res. G-3601. In the revised 2023 Research Plan, each of the subprograms' Funding Allocation table reflects this redistribution.

- How SoCalGas proposes to demonstrate how its hydrogen programs and projects will utilize clean, renewable hydrogen (CRH), consistent with the definition given in Decision (D.) 22-12-057.

- Supplemental information in Appendix E about blending projects that are carried under the System Inspection and Monitoring subprogram, including highlighting aspects that demonstrate how those projects complement and support the efforts under the hydrogen blending pilots conducted through D.22-12-057 without being duplicative.

- Expansion of the Equity section of the Revised 2023 RD&D Research Plan to provide greater detail about how SoCalGas's proposed projects and strategies benefit Environmental and Social Justice (ESJ) communities. Additional information is also being provided about the development of its impact analysis framework and how it plans to incorporate guidance from the Uniform Impact Analysis Framework efforts in Res. 19-10-005.[2]

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[1] https://tariff.socalgas.com/regulatory/tariffs/tm2/pdf/submittals/GAS_5991.
[2] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M507/K499/507499284.PDF

- Supplemental information about RD&D participation in consortiums including justification of consortium dues to clarify how these efforts can benefit ratepayers.

All revisions to the initial 2023 RD&D Research Plan associated with Res. G-3601 are specifically identified under Revisions pursuant to Res. G-3601 throughout this document and redlined as directed.

1.1 RD&D Program Goals and Structure

The goals of the RD&D program are to identify, test, and commercialize transformational new energy technologies that will reduce GHG and criteria air pollutant emissions, maintain the energy affordability that natural gas has historically provided, and advance the safety and reliability of California's gas delivery networks and systems in an ever-changing operational environment.

SoCalGas RD&D is divided into five programs, each of which is focused on products and technologies united by a broad theme such as transportation or end-use applications. Programs remain constant from year to year.

Each program is, in turn, broken into multiple subprograms. Each subprogram focuses on a subset of the program theme. Subprograms remain relatively constant but can change in response to industry developments, guidance from the California Public Utilities Commission (CPUC), or stakeholder input.

Each subprogram includes several research areas. These forward-looking categories suggest the types of projects RD&D hopes to fund. Staff evaluate research areas annually. Research areas are non-exhaustive; RD&D can and does fund or otherwise support projects that do not fall within a defined research area.

In 2023, SoCalGas RD&D intends to allocate funding across five programs—Low Carbon Resources, Gas Operations, Clean Transportation, Clean Generation, and Customer End-Use Applications—and multiple associated subprograms.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring eight subprograms in 2023: Carbon Capture, Utilization, & Sequestration, Off-Road, Onboard Storage, On-Road, Refueling Stations, Distributed Generation, Industrial Process Heat, and Residential Appliances. For each of these retired subprograms, SoCalGas is designating as "Actual Incurred Cost" those costs incurred and paid by RD&D in 2023 up to the issuance of G-3601 for work in multi-year agreements that were executed before Dec 31, 2022. SoCalGas also provides "Estimated Incurred Costs" for multiyear agreements in which costs were incurred up to the issuance of G-3601, but an invoice has not yet been received and/or paid, which are also proposed to be allocated as shown in the revised funding allocation table for each of these subprograms. Remaining funds under each retired subprogram that have not been previously incurred are shown as "Funds Available for Reallocation" and are distributed to different subprograms approved by Res. G-3601. More information is provided in the revised Section 6 – Proposed 2023 Funding Allocations.

Table 2: The RD&D Program is divided into five programs and 17 subprograms.[3]

Programs	Subprograms
Low Carbon Resources	Carbon Capture, Utilization, & Sequestration (Retired)
	Renewable Gas Production
Gas Operations	Environmental & Safety
	Operations Technology
	System Design & Materials
	System Inspection & Monitoring
Clean Transportation	Off-Road (Retired)
	Onboard Storage (Retired)
	On-Road (Retired)
	Refueling Stations (Retired)
Clean Generation	Distributed Generation (Retired)
	Integration & Controls
Customer End-Use Applications	Advanced Innovation
	Commercial Applications
	Commercial Food Service
	Industrial Process Heat (Retired)
	Residential Appliances (Retired)

Within each sub-program, RD&D Program staff take a comprehensive yet flexible approach when identifying promising projects and evaluating them for potential funding. This approach enables them to 1) identify potential projects most in alignment with RD&D Program goals, state and federal environmental policy, and industry demand; 2) accurately assess the likelihood of potential projects to succeed; 3) work with proven partners and technologies over time; and 4) respond nimbly to changing market, technology, and policy drivers. More details about the Project Selection Process and Evaluation Criteria can be found in Appendix D of this document.

[3] Retired subprograms are those that were ongoing and are now being retired pursuant to the CPUC's directives in Res. G-3601.

2 Regulatory and Policy Drivers

RD&D staff consider a variety of factors in determining how to broadly allocate funding. These factors include regulatory and policy drivers, input from knowledgeable stakeholders, input from the California Public Utilities Commission (CPUC) Energy Division staff and other interested parties at an annual workshop, and the potential impact of research on environmental and social justice (ESJ) communities. The process is designed to optimize subprogram-level funding allocations, to provide an opportunity for stakeholder input, and to maximize progress toward overarching program goals and objectives.

Table 3: Key state and federal policies and regulations impacting SoCalGas RD&D.

Category	Regulations and Policy Drivers
GHG Emissions	**AB 32:** Reduce carbon dioxide (CO_2) emissions 40% below 1990 levels by 2030 **SB 100:** Zero-carbon electricity by 2045 **EO B-55-18:** Carbon-neutral California economy by 2045 **AB 3232:** Reduce GHG emissions from residential and commercial buildings by 40 below 1990 levels by 2030 **SB 1101:** Carbon Sequestration: Pore Space Ownership and Carbon Capture, Utilization, and Storage Program
Pipeline Safety	**CPUC General Order 112F:** Rules governing design, testing, operation, and maintenance of gas transmission and distribution (T&D) systems **U.S. Department of Transportation (DOT) 49 Code of Federal Regulations (CFR) Part 192:** Federal pipeline safety regulations **AB 1900:** Biomethane quality standards **Order Institute Rulemaking (OIR) R.13-02-008, Phase 4:** Addresses injection of renewable hydrogen into gas pipelines
Local Air Quality	**Clean Air Act:** Air quality standards for nitrogen oxides (NOx) and particulate matter (PM) **AB 617:** Nonvehicular air pollution: criteria air pollutants and toxic air contaminants
Clean Transportation	**ARB Implementation Plan:** Low-NOx standard for trucks **AB 8:** Development of 100 hydrogen fueling stations in California **EO B32-15:** Sustainable freight action plan **EO B48-18:** 200 hydrogen refueling stations by 2025 **EO N-79-20:** 100% of MHDs be zero emission by 2045 for all operations where feasible **Low Carbon Fuel Standard (LCFS):** Reduce carbon intensity of fuels by 10% by 2020 **SB 1275:** One million zero-emission and near-zero-emission vehicles by 2023

Equity	**General Order 156:** Encourages investor-owned utilities (IOUs) to procure or contract goods and services from women-, minority-, disabled veteran- and/or LGBTQ-owned business enterprises **CPUC ESJ Action Plan:** Increase investment in clean energy resources to benefit ESJ communities, especially to improve local air quality and public health
Methane Emissions	**SB 1383:** Reduces methane emissions from decomposition of organic wastes **SB 1440:** Authorizes a state procurement program for biomethane **CARB Oil and Gas Rules:** Requires new monitoring and repairs to reduce methane emissions **Natural Gas STAR Program:** Encourages adoption of methane-reducing technologies and practices **EPA Methane Challenge Program:** Recognizes oil and gas companies that take comprehensive action to reduce methane emissions

3 Stakeholder Input

3.1 Stakeholder Outreach

SoCalGas RD&D works closely with industry professionals and SMEs at universities, national labs, public agencies, businesses, and industry research consortia to maximize the impact of its funding of promising technologies and products focused on producing or delivering cleaner, safer, affordable, and more reliable energy. These relationships enable SoCalGas to engage with science and technology experts, other utilities, and industry stakeholders to effectively identify and close knowledge and research gaps, avoid duplication of previous and ongoing research, and reduce technology and commercialization risks to achieve the goals of SoCalGas RD&D.

Conversations with these stakeholders and SMEs are ongoing throughout the year, but in preparation for the 2023 funding allocations, RD&D Program staff also conducted a series of targeted interviews with 15 people from 11 different organizations in the first quarter of 2022. During these interviews, the SMEs and industry stakeholders were asked a series of standard questions and then engaged in a freeform discussion about the industry and its RD&D needs. See Appendix A for a summary of responses.

Table 4: RD&D Program staff conducted stakeholder interviews with 15 individuals from 11 different organizations in early 2022.

2022 Stakeholder Organizations Interviewed	
Bakersfield College	National Renewable Energy Laboratory
California Energy Commission	Northeast Gas Association/NYSEARCH
California State University, Long Beach	Pipeline Research Council International
California State University, Los Angeles	Stanford Natural Gas Institute
GTI Energy	U.S. Department of Energy

Kern Oil

3.2 Annual Stakeholder Workshop

On April 27, 2022, SoCalGas RD&D hosted an online workshop to present the results of the previous year's program and obtain input regarding proposed spending allocations for 2023. SoCalGas RD&D staff publicly announced the workshop on the SoCalGas RD&D website and LinkedIn page and by email to members of the A.17-10-008, R.19-10-005, R.20-01-007, R.19-01-011, and R.13-11-005 service lists.

248 individuals from a wide variety of organizations attended the workshop. Organizations sending attendees included four national laboratories, four public agencies, and numerous industry organizations, universities, community-based organizations (CBOs), and private companies.[4]

2022 Annual Stakeholder Workshop Attendee List

Accenture	Global Water Advisors, Inc.
Agility	Greater Ontario Business Council
Air Products and Chemicals, Inc.	Green Impact Partners
Alexander Talks	Gregori Consulting LLC
Allawos & Company	Gridworks
Alliance North America	GTI Energy
American Gas Association	H2 Energy Group, Inc.
ANGI Energy Systems	H2U Technologies
Argonne National Laboratory	Heliogen
AISIN Corporation	Hermandad Mexicana Nacional
Aspen	Home Energy Analytics, Inc.
ATCO Ltd.	Hy Stor Energy
Berokoff Energy Solutions	Hyperlight Energy
BEST LLC	Hyteon, Inc.
Brubaker & Associates, Inc.	Immaterial Ltd.
Burns & McDonnell	InterAct PTMI
California Energy Commission	Jay Luboff Consulting LLC
California Fuel Cell Partnership	Los Angeles Department of Water and Power
California Institute of Technology	Mar Vista Family Center
California League of Food Producers	Massachusetts Hydrogen Coalition
California Public Utilities Commission	MCE Clean Energy
California State University, Los Angeles	Mehta Associates
Calpine Corporation	Middle River Power LLC
Capgemini	Momentum
Capstone Green Energy	NASA Jet Propulsion Laboratory
Chevron	National Grid
Clean Energy	National Renewable Energy Laboratory
Custom Alloy Sales, Inc.	Nel Hydrogen
DAC	New Jersey Natural Gas

[4] To encourage participation by CBOs, RD&D provided stipends to several to cover their time attending the workshop.

Del Rey Consultancy	New York State Electric & Gas Corporation
Department of Energy, Hydrogen & Fuel Cell Technologies	NGVAmerica
E2 Consulting Engineers, Inc.	Northridge East Neighborhood Council
EEG Energy Gas	Northwest Energy Efficiency Alliance
Electric Power Research Institute, Inc.	NW Natural Gas Co.
Energy Capital Ventures	NYSEARCH/Northeast Gas Association
ENGIE	Oak Ridge National Laboratory
Florence Firestone Merchants Association	OMC Hydrogen, Inc.
FM Global Holdings	Osaka Gas USA
Frontier Energy	Pacific Gas & Electric
FuelCell Energy, Inc.	Pacific Northwest National Laboratory
Galileo Technologies	Palo Alto Research Center
Gazomat	Peoples Gas
GenCell Energy	Plains Midstream Canada
General Motors	Quaise Energy Limited
GKN Hydrogen	RealEnergy

3.3 Stakeholder Input

During the five-hour workshop, RD&D team members presented the following topics:

- 2021 in Review
- Program Status and Updates for 2022
- Draft Research Plan for 2023

At the end of each section of the presentation, the RD&D team fielded questions and comments from attendees. SoCalGas also posted a link to the workshop recording on the SoCalGas RD&D web page.[5] A complete list of the questions received during and following the workshop, along with answers from appropriate SoCalGas personnel, is included in Appendix B and Appendix C. See also Section 5.1 for more information about the response of SoCalGas RD&D to stakeholder input.

[5] https://www.socalgas.com/sustainability/research-development-demonstration-rdd

4 Equity

4.1 Environmental and Social Justice Communities and Climate Change

In California, millions of people live and work in areas categorized as ESJ communities, a designation that includes disadvantaged communities (DACs), tribal lands, and low-income households and census tracts. All too often, people from ESJ communities suffer disproportionate environmental and socioeconomic impacts, including poverty, high unemployment, air and water pollution, and high incidences of asthma and heart disease. In many cases, ESJ community residents also suffer from reduced or less reliable access to energy. What energy they can access often represents a burdensome percentage of their household incomes.[6]

Critically, members of ESJ communities are at greater risk from the negative impacts of climate change. According to the Fourth National Climate Assessment:

> *Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.*[7]

Further:

> *Impacts within and across regions will not be distributed equally. People who are already vulnerable, including lower-income and other marginalized communities, have lower capacity to prepare for and cope with extreme weather and climate-related events and are expected to experience greater impacts. Prioritizing adaptation actions for the most vulnerable populations would contribute to a more equitable future within and across communities. Global action to significantly cut greenhouse gas emissions can substantially reduce climate-related risks and increase opportunities for these populations in the longer term.*[8]

4.2 Diversity, Equity, and Inclusion at SoCalGas

SoCalGas is committed to equity, diversity, and inclusion. SoCalGas is an Affirmative Action and Equal Employment Opportunity employer and considers all applicants for employment without regard to race, color, religion, sex, gender identity, gender expression, sexual orientation, national origin, age, handicap or disability status, or status as a protected veteran under state and federal law.

In 2021, the company awarded $972.6 million in SoCalGas contracts—a 10% increase over 2020 and the highest total in SoCalGas history—to 577 certified Diverse Business Enterprises (DBEs). This represents 42.42% of the company's total purchases with suppliers.[9] Importantly, this total marks the 29th consecutive time that SoCalGas

[6] https://www.energy.gov/sites/prod/files/2019/01/f58/WIP-Energy-Burden_final.pdf
[7] https://nca2018.globalchange.gov/#
[8] https://nca2018.globalchange.gov/#
[9] https://www.socalgas.com/for-your-business/supplier-diversity

exceeded the CPUC's goal of 21.5% of total procurement of goods and services from women, minority, service-disabled veteran, and LGBTQ-owned businesses.

The company is also actively fulfilling the commitments of the CEO Action for Diversity & Inclusion, a pledge by more than 900 companies worldwide to advance diversity and inclusion in the workplace. To reinforce the SoCalGas vision of a workplace where everyone feels like they belong and are able to thrive, the company's Diversity & Inclusion department offers several ways for employees to be involved, including:

- Five Diversity & Inclusion Councils
- A Diversity & Inclusion Mentoring Program
- An Annual Diversity & Inclusion Summit
- Affinity groups for Black and Latino employees
- The VALOR program that helps provide a smooth transition for newly hired SoCalGas veteran/active military employees

SoCalGas believes in not only lending a hand, but also empowering people with a hand up, so they can further develop, grow, and subsequently empower others. The company's goal is to focus on charitable giving initiatives that create positive ripple effects throughout the community we serve and truly make a better world. Recently, the SoCalGas Charitable Giving Report was converted into a quarterly video and magazine series entitled *Empower*,[10] where stakeholders can learn more about the diverse personal human impacts that our charitable initiatives create.

4.3 Equity in SoCalGas RD&D

Equity is one of the program's core values and a factor it considers in every funding allocation decision. SoCalGas RD&D seeks to advance and champion technologies that support widespread access to clean, affordable, and reliable energy for all Californians, including those living and working in ESJ communities. To achieve these goals, SoCalGas RD&D:

- Seeks to locate projects in under-resourced communities
- Supports diverse research teams that include members from disadvantaged and underrepresented groups
- Shares the results from RD&D projects to inform and educate the public
- Reports its progress in diversity and inclusion efforts in its Annual Report

SoCalGas RD&D also regularly engages with diverse academic populations at universities and colleges to foster new researchers. Examples of this activity include:

- **Cal State LA Engineering, Computer Science, & Technology Capstone Senior Design Program**
  Cal State LA is a public university known for serving numerous Hispanic, Asian American, Pacific Islander, and minority students. Many are from low-income families and are the first in their families to attend college. The university is ranked number one in the nation for upward mobility, in part due to programs such as its Engineering, Computer Science, & Technology Capstone Senior Design

[10] https://www.socalgas.com/our-community/empower

Program. Each year, funded by corporate and university sponsorships, the program gives students open-ended, real-world problems to solve. Working in small groups, the students meet with faculty advisors and project sponsors, work collaboratively, learn new skills, and present their results to faculty and sponsors. See page 17 of the SoCalGas RD&D 2021 Annual Report for a relevant case study.

- **Community Outreach**
  On August 25, 2021, SoCalGas RD&D hosted representatives from Cypress College, Pasadena City College, Santa Barbara City College, Kern Community College District, East Los Angeles College Engineering & Technologies, Bakersfield College, Cerritos Community College, and Saddleback College. RD&D staff sought to understand how the program could help the participants meet their goals and solicited input on their key concerns, including energy affordability, safety, air quality, and emissions.

- **H2GP: Horizon Hydrogen Grand Prix**
  With support from numerous corporate sponsors, Horizon Educational conducts a global competition among high school students seeking to design and build a hybrid car powered by a hydrogen fuel cell. Representatives from SoCalGas RD&D have served as judges for the competition in the past. In 2022, SoCalGas plans to sponsor teams, with a particular focus on schools located in under-resourced communities.

SoCalGas RD&D also solicits input from community-based organizations and seeks to incorporate input from them into its planning efforts. For example, on February 24, 2021, SoCalGas RD&D met with representatives from Home Aid Orange County, Proteus Inc., Pomona Chamber of Commerce, Unity Shoppe Santa Barbara, Santa Barbara Zoo, Southeast Community Development Corporation, Family Assistance Ministries, El Concilio Family Services, and Family Service Association. RD&D Program staff presented material about new technologies with the potential to benefit disadvantaged communities and priority populations. Attendees raised concerns about energy reliability and its relation to storing medications or preparing meals. Affordability of both energy and the new technologies was a key concern.

<u>Revisions pursuant to Res. G-3601:</u>

SoCalGas proposes to conduct a series of studies, in coordination with Energy Division staff and the ESJ Advisory Panel, to continue to build upon existing efforts, including the RD&D's Equity Engagement Roadmap (EER), addressing the needs of the ESJ communities that contribute to the RD&D program. These studies would be designed to determine, either through literature review or primary research, the customer composition in these communities (e.g., residential, commercial, or industrial), the priorities of the members of these communities within the SoCalGas service territory, technical data (e.g., type and vintage of equipment deployed, types of vehicles owned or operated in the community, and air pollution sources within these communities), and demographic data (e.g., household income, vocations, and housing type).

This information would help RD&D to develop a plan that can focus on the key issues impacting these more vulnerable communities. RD&D proposes to present the plan to the ESJ Advisory Panel and other stakeholders (e.g., Energy Divisions staff and CEC staff) for feedback and input before implementation.

Furthermore, RD&D anticipates integrating this information into a specific set of requirements within the Uniform Impact Analysis Framework (UIAF) to address the specific needs of ESJ communities within SoCalGas' service territory.

4.4 Equity Engagement Roadmap Update

Disenfranchised communities are often left out of the decision-making process. This can result in ill-fated policy and implementation efforts that do not address their actual needs. To effectively engage with historically underserved communities, better understand their needs, and improve its operational response to these needs, SoCalGas RD&D began development of a multi-year public-facing Equity Engagement Roadmap in 2021. To develop this plan, SoCalGas RD&D has completed the following activities:

- Engaged with 2020Vet, a woman- and veteran-owned consulting firm to help develop the roadmap.
- Conducted a literature review of more than 50 ESJ documents, NGO publications, and academic reports produced by federal, state, and local government, private industry, and utilities. Among these documents was the CPUC's ESJ Action Plan.
- Identified general themes and industry best practices.
- Developed three key themes for the roadmap:
    - Obtain situational awareness
    - Increase community engagement
    - Institutionalize equity engagement
- Developed a draft plan with RD&D action items to address the key themes.
- Coordinated with 2020Vet to seek input from ESJ and diversity, equity, and inclusion (DE&I) experts and incorporated feedback into the draft plan.

In August 2023, SoCalGas RD&D issued an updated version of its Equity Engagement Roadmap, or EER.[11] The EER identified three themes and six specific tasks to guide RD&D's ongoing engagement efforts and to develop, update, and track equity engagement metrics that SoCalGas leadership, the CPUC, and the public can use to evaluate the degree to which the projects supported by SoCalGas RD&D address inequities related to climate, income, and race/ethnicity, age, and other diversity dimensions in the communities served by SoCalGas.

Task 1 of the EER guides RD&D to "Monitor and report key RD&D Equity Engagement project metrics in the RD&D Annual Report." As part of this task, the 2022 RD&D Annual Report[12] (and the Spanish version, "2022 Informe Annual"[13]) include a map of RD&D projects located in ESJ Communities. In 2022, 61 RD&D projects were located in ESJ Communities.

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[11] https://www.socalgas.com/sites/default/files/2023-08/SoCalGas_RDD_Equity_Engagement_Roadmap.pdf.
[12] https://www.socalgas.com/sites/default/files/2022_SoCalGas_RDD_Annual_Report.pdf#page=[17]
[13] https://www.socalgas.com/sites/default/files/2022_SoCalGas_RDD_Informe_Anual.pdf#page=[17]

Task 6 of the EER guides RD&D to "review/revise RD&D project policies to include DEI components." As part of this task, RD&D updated its project evaluation process to include "Equity Component" field in the project description as well as to add "Equity Consideration" to the list of project evaluation criteria. These additions are designed to encourage RD&D and the research project teams to consider adding components to project scopes to consider environmental justice communities, enhance community engagement, and improve diversity of research teams.

Examples of these additions include:

- The scope of work (SOW) for the project, "GTI Energy Mobile Hydrogen Fuel Cell Generation System Demonstration (CEC MORBUGS)," includes a task to engage disadvantaged, low-income, and Tribal community stakeholders to raise their awareness of the benefits of the technology as well as increase their participation in the RD&D activity within their neighborhoods.
- The SOW for the project, "NREL Grid Forming Inverters for Fuel Cells Research," instructs NREL to create a subcontract with a university partner to support the fuel cell modeling efforts and diversity, equity, and inclusion (DEI) efforts. In support of this requirement, UCI hosted two high school outreach projects in 2023.
- The SOW for the project, "GTI Hydrogen Blend Burner Design Analysis and Guidelines Research," includes a task directing the project team to survey the types of gas appliances found in Disadvantaged Communities in SoCalGas' service territory and collect information about the community members' current knowledge, impression, and concerns hydrogen-blended gas deployment.

The results of these project components will be included in the final reports produced by each project and made available to the public. In response to OP 3.d, SoCalGas will work to include these ESJ focused project components and any available results in future Annual Reports to the Commission.

To better measure the impact of RD&D projects on disadvantaged and low-income communities in terms of job creation and other economic development, SoCalGas RD&D is working closely with the Energy Division of the California Public Utilities Commission to develop suitable metrics and an evaluation framework (see Section 5.2).

On July 29, 2022, SoCalGas submitted AL 6014-G, which created the foundational principles for a Benefits Analysis Framework. Al 6014-G was approved by the CPUC on August 28, 2022. In D.23-04-042, issued April 28, 2023, the Commission found that the term "benefits analysis framework" should be now called the "uniform impacts framework," further explaining that "research and development projects have an element of risk, which means that not all EPIC projects will directly benefit ratepayers in a quantifiable manner." In support of these directives, SoCalGas RD&D proposes to make ongoing improvements to the UIAF, adapting as informed by the process and outcomes of proceeding R.19-10-005, participating in upcoming EPIC workshops, and continuing to work in consultation with Energy Division staff as directed in Res. G-3586.

5 New in 2023

5.1 Response to Stakeholder Input

Through ongoing conversations throughout the past year and an intensive outreach process conducted during the first quarter of 2022, RD&D staff identified many key issues important to stakeholders. These issues are summarized in:

- Appendix A: Stakeholder Input
- Appendix B: Public Workshop Questions & Comments
- Appendix C: Post-Workshop Stakeholder Input

Generally, RD&D staff confirmed that program areas, subprograms, and research areas were in alignment with how key stakeholders from relevant universities, national labs, research consortia, and businesses view the needs of the industry. When appropriate, SoCalGas RD&D incorporates input received into its research plans.

Figure 1: The SoCalGas RD&D Annual Outreach Program revealed numerous themes.

In 2022, several key themes emerged from stakeholder input. SoCalGas RD&D staff carefully reviewed this year's input (Appendices A, B, and C) and considered them against RD&D project selection criteria (Appendix D). Foremost among the identified themes were:

Outreach Takeaway	SoCalGas RD&D Strategy
Hydrogen is a key technology for decarbonization.	Across all of its program areas, SoCalGas RD&D is exploring the role of hydrogen in

A majority of outreach targets (Section 3.1) stressed the importance of exploring the role of hydrogen in the decarbonization of energy production, delivery, and end-use applications. From leveraging existing gas infrastructure and developing refueling options for heavy-duty trucks to exploring new ways to produce hydrogen that minimize water consumption, the consensus was that hydrogen is a key technology for decarbonization.	the decarbonization of energy. See Sections 7.3.3 (Areas 1, 3, 4), 8.5.3 (Areas 1, 3), 9.2.3 (Areas 1, 2, 3, 4), 9.3.3 (Area 1), 9.4.3 (Areas 1, 2), 9.5.3 (Areas 1, 2), 10.2.3 (Areas 1, 2), 11.3.3 (Area 2), 11.4.3 (Area 1), 11.5.3 (Area 2), and 11.6.3 (Area 1).
Support Carbon Capture, Utilization, and Storage (CCUS) projects. Many respondents indicated support for CCUS technologies—including direct air capture—and some stressed the need for developing commercial-scale projects to demonstrate that the technologies actually work.	SoCalGas RD&D supports CCUS projects through its Low Carbon Resources program. See Section 7.2.
Increase project equity. Some respondents recommended increasing the diversity of SoCalGas RD&D through greater engagement with student programs, locating projects in areas categorized as disadvantaged or low-income, and adding people from underrepresented groups to project teams.	Equity is a core and growing focus of SoCalGas RD&D. See Sections 4.3, 4.4, 7.2.5, 7.3.5, 8.2.1, 9.2.5, 9.3.5, 9.4.5, 10.2.5, 10.3.5, 11.2.5, 11.3.5, 11.4.5, 11.5.5, and 11.6.5.
Focus on improving the affordability of energy. Some respondents stressed the importance of pursuing technologies and projects that reduce energy costs for members of ESJ communities.	SoCalGas RD&D is keenly interested in improving the affordability of energy. Of the 379 projects it supported in 2021, 107 of them directly or indirectly would improve energy affordability. See Sections 7.3.4, 8.2, 9.2.4, 9.3.4, 9.5.4, 10.2.4, 10.3.4, 11.2.4, 11.3.4 11.4.4, 11.5.4, and 11.6.4.
Support development of RNG and low-carbon fuels RNG and other low-carbon fuels came up frequently in discussions with stakeholders.	SoCalGas RD&D explores and supports development of RNG and other low-carbon fuels. See Sections 7.2.3 (Areas 1, 2), 7.3.3 (Areas 2, 3, 5), 8.5.3 (Areas 1, 3), 9.2.3 (Area 3), 9.3.3 (Area 1), 9.5.3 (Area 1), 10.2.3 (Area 3), 10.3.3 (Area 2), 10.4.3 (Area 1), and 11.6.3 (Area 1).
Focus on system integrity. Stakeholders expressed interest in continuing research on how to support existing gas infrastructure through artificial intelligence (AI), data standards, and inspection technologies.	System integrity is a key focus of several RD&D research areas. See Sections 8.4.3 (Areas 1, 2), 8.5.3 (Areas 1, 2, 3), and 8.6.3 (Areas 1, 2, 3, 4).
Workforce development and education are vital to the energy transition. Numerous outreach respondents expressed a need for workforce development and training for students,	SoCalGas RD&D actively supports workforce development and education efforts in the projects it supports. In many cases, RD&D projects set the stage for future workforce development and

technicians, first responders, and engineers in hydrogen and other new technologies. Some also spoke of the importance of educating policy makers and legislators about the safety and reliability of natural gas, hydrogen, and RNG, as well as realistic timelines for the energy transition.	education activities. See Sections 4.3, 8.3.3 (Area 3), and 8.4.1.

5.2 Alignment with California's Decarbonization Goals

AB3232 requires California residential and commercial building stock to reduce their GHG emissions level by at least 40% below 1990 emissions levels (23.6 MMTCO2e) by 2030. According to a 2019 study by the Energy Future Initiative, even if the state enacted aggressive electrification policies and electrified 22% of residential buildings and all new construction by 2030, this would only equate to about 3.9 MMTCO2e in emissions reduction by 2030 or a 10% reduction from 2016 building emissions (39.4 MMTCO2e).

In comparison, energy efficiency has contributed to a decrease in the sector's emissions since 2000, despite the sector's growth since then. According to the California Energy Commission (CEC), mandatory energy efficiency codes and standards, plus programs that incentivize emissions reductions through behavioral and financial mechanisms, equates to a reduction of 8.4 MMTCO2e by 2030. Technology development that improves the energy efficiency of end-use gas appliances would only further drive emissions reduction potential. Therefore, a diversified pathway that includes improved energy efficiency, building retrofits, and fuel-switching (i.e., RNG, hydrogen, and electrification) will enable California to achieve its short- and long-term building decarbonization goal more cost-effectively and expeditiously.

While there is strong technical potential for each of these measures to play a role in reducing emissions, it is important to consider the impacts to buildings and homeowners involving costs, consumer preferences, and potential for disruption. It is critical to acknowledge that electricity and gas complement each other—both are needed and can reinforce each other. Taking a systemwide view of energy infrastructure that recognizes the value and coordinates the gas and electric systems to manage decarbonization affordability and resiliency provides the greatest overall benefits. One of the gas system's main strengths is its ability to meet extreme peaks. It can store, quickly ramp up, and deliver high volumes of energy on short notice and can handle large changes in volumes over time without operational, reliability, or financial strain. Without the inherent benefit of the gas system, the electricity system would be overburdened during the most crucial moments when our ratepayers need energy. For example, the electricity system currently struggles to meet peak summer loads. While these scenarios do not generally create a human life crisis, the complete removal of the gas system may create a winter seasonal peak demand for the electricity system. The gas system's seasonal peak is in the winter when heating load is the highest. Without the natural gas resiliency in the winter, a completely electrified energy infrastructure could pose a significant concern for heating loads resulting in loss of life. Therefore, a diversified energy system gives us the versatility to meet peak energy demand seasonally.

5.3 Coordination with CEC and Other IOUs

SoCalGas RD&D is committed to coordinating with the CEC; other government agencies including the California Air Resources Board (CARB), the South Coast Air Quality Management District (SCAQMD), and the U.S. Department of Energy (DOE), and other IOUs and municipal owned utilities.

One way that SoCalGas RD&D coordinates with others in the research community is through its annual public workshop. This year, the workshop was attended by representatives from the CEC and IOUs from across North America, including ATCO, ENGIE, Los Angeles Department of Water and Power (LADWP), National Grid, New Jersey Natural Gas, New York State Electric & Gas Corporation, NW Natural Gas Co., Pacific Gas & Electric Company (PG&E), and Peoples Gas (Section 3.2).

On January 31, 2022, SoCalGas submitted comments on the January 19, 2022, CEC Gas R&D Workshop. The comments addressed the CEC's research initiative to study hydrogen blending in power generation applications and included citations for the following SoCalGas RD&D projects:

- UCI Effect of Hydrogen Addition into Natural Gas on SCR of NOx Lab Testing
- UCI Fuel Flexible Microturbine Generator Development
- UCI Fuel Flexible Rotary Engine MicroCHP Development

In response, CEC staff commented that they will track these SoCalGas RD&D projects, since the results from these projects may inform future CEC solicitation development. CEC staff has subsequently contacted RD&D staff to discuss these projects in detail.

SoCalGas RD&D also engages and coordinates with other IOUs through involvement with national research consortia. These consortia are made up of IOUs and other researchers. Their intent is to leverage funding, expertise, and collaboration to maximize the value of research projects and avoid duplication of R&D efforts. In addition, the research consortiums meet with other organizations and agencies to discuss on-going and future research plans to avoid duplication[14], publish public Annual Reports[15] which summarize their work, and develop project proposals in response to agency funding opportunities. For example, CEC funding typically requires cost share to win an award. The OTD and UTD research consortiums monitor CEC solicitations as a mechanism to further leverage critical research dollars. Industry-led research consortiums such as UTD and OTD not only provide cost-share to projects, but also provide industry technical representation and input. See Section 6.2 for more detail about SoCalGas RD&D's participation in research consortia.

SoCalGas RD&D also works directly with other utilities to advance technologies that will benefit all Californians. SoCalGas RD&D recently collaborated with PG&E to support the

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[14] For examples of research consortium affiliate organizations, please see: https://www.prci.org/About/PartnersAffiliates.aspx, https://www.utd-co.org/members/, and https://primis.phmsa.dot.gov/rd/workshops.htm.

[15] For examples of research consortium annual reports, please see: https://www.utd-co.org/wp-content/uploads/2021/12/UTD_Annual_Report_Research_Project_Summaries_2020-21.pdf, https://www.otd.org/wp-content/uploads/2021/10/OTD-Research-Project-Summaries-2020.pdf, https://www.nysearch.org/tech-brief-pdfs/2NYSearchBookUPDATEDFINALWEBFILE.pdf.

development of Brimstone Energy's low-cost, low-energy hydrogen and sulfuric acid co-production via electrolysis technology.[16] SoCalGas RD&D is currently working with LADWP and the DOE's Advanced Research Projects Agency-Energy to support a rapid temperature swing adsorption system for CO2 capture.[17]

SoCalGas RD&D regularly participates in CEC funding solicitations and is working with the CEC on a number of co-funded projects. In April 2022, the CEC announced proposed award funding for three hydrogen production technology projects supported by RD&D. The CEC is providing nearly $5 million to the awardees, with $1.9 million awarded to the University of Southern California for catalytic reformer development and $750,000 each to the University of California, Los Angeles and Susteon for hydrogen production technology development. To support these projects, SoCalGas RD&D committed a total of $700,000 to these projects. Also in April 2022, the CEC awarded GTI Energy and the University of California, Irvine $1.8 million to study the cost-performance-safety implications and emissions benefits of adopting up to 100% hydrogen to decarbonize large commercial buildings and industrial applications. SoCalGas committed a total of $700,000 with an additional $1 million in co-funding from PG&E, UTD, EPRI, and others to support this research.

[16] Renewal: SoCalGas RD&D 2021 Annual Report, p. 81
[17] Id. p.74

6 Proposed 2023 Funding Allocations

6.1 Proposed 2023 Funding Allocations

The total authorized funding for the RD&D program was set by the 2019 General Rate Case (GRC) decision, which established the authorized funding for test year 2019 and the escalation and attrition rates for each subsequent year in SoCalGas' rate case cycle, including 2023. The total authorized funding for 2023 is $16,874,000.[18] Of that total, SoCalGas RD&D will allocate approximately 10% or $1,687,400 to program administration. Activities in the Program Administration Budget were organized to align with allowable EPIC administration cost categories developed in the process launched by D.21-11-028.

Program Administration Budget Items	**2023 Forecast**
Investment Plan Development	$170,000
Project Initiation	$104,008
Project Oversight and Governance	$26,002
Stakeholder Communication, Engagement, and Outreach	$430,000
Regulatory Support and Compliance	$450,952
Internal Management Coordination	$62,738
Program and Process Coordination and Improvement	$156,845
Administration Activities	$130,009
Supervision and Personnel	$125,476
Training and Development	$31,370
Total	**$1,687,400**

[18] Any over- or under-spend from 2022 will be applied to 2023 in accordance with Resolution G-3573.

Table 5 6: Revised RD&D Program Proposed 2023 Funding Allocations by Program and Subprogram.

Programs	Initial Program Funding	Subprograms	Initial Subprogram Funding	Incurred Costs [a]	Available for Reallocation	Reallocated Funds	Revised Subprogram Funding	Revised Program Funding
Low Carbon Resources	$5,619,042	Renewable Gas Production	$2,809,521	-	-	$1,122,084	$3,931,605	**$4,777,158**
		CCUS (Retired)	$2,809,521	($845,553)	$1,963,968	-	$845,553	
Gas Operations	$3,644,784	Environmental & Safety	$728,957	-	-	$250,000	$978,957	**$4,394,784**
		Operations Technology	$546,718	-	-	$250,000	$796,718	
		System Design & Materials	$1,457,913	-	-	$250,000	$1,707,913	
		System Inspection & Monitoring	$911,196	-	-	-	$911,196	
Clean Transportation	$2,126,124	Off-Road (Retired)	$637,837	($196,036)	$441,801	-	$196,036	**$1,134,579**
		Onboard Storage (Retired)	$425,225	$0	$425,225	-	$0	
		On-Road (Retired)	$637,837	($756,841)	($119,004)	-	$756,841	
		Refueling Stations (Retired)	$425,225	($181,702)	$243,523	-	$181,702	
Clean Generation	$1,670,526	Distributed Generation (Retired)	$835,263	$0	$513,929 [b]	-	$321,334	**$2,061,741**

		Integration & Controls	$835,263	-	-	$905,144	$1,740,407	
Customer End-Use Applications	$2,126,124	Advanced Innovation	$127,568	-	-	$100,059	$227,627	**$2,013,401**
		Commercial Applications	$318,919	-	-	$250,146	$569,065	
		Commercial Food Service	$148,829	-	-	$54,880	$203,709	
		Industrial Process Heat (Retired)	$850,450	$0	$257,222 [b]	-	$593,228	
		Residential Appliances (Retired)	$680,359	($419,772)	$260,587	-	$419,772	
Program Administration	$1,687,400	-	-	-	-	-	$1,687,400	**$1,687,400**
Comprehensive Gas RD&D database	-	-	-	-	($129,938) [c]	-	$129,938	**$129,938**
Comprehensive RD&D program evaluation	-	-	-	-	($675,000)[c]	-	$675,000	**$675,000**
Total			**$16,874,000**	($2,399,904)	$3,182,313	$3,182,313	$16,874,000	**$16,874,000**

[a] Includes actual and estimated incurred costs (Jan-Nov '23).
[b] Remaining funds for reallocation after discounting funds needed to complete in-progress projects as directed by Ordering Paragraph 8 of Res. G-3601.
[c] Funds directed to specific initiatives as directed by Ordering Paragraph 3.a of Res. G-3601.

Revisions pursuant to Res. G-3601:

Resolution G-3601 directed SoCalGas to modify its proposed RD&D funding allocation. To develop its revised proposal for 2023 funding allocation shown in Table 5, SoCalGas followed the guidance provided by the Resolution as discussed in this section.

Resolution G-3601 approved SoCalGas RD&D proposed allocation for the following subprograms as long as SoCalGas demonstrates the use of clean renewable hydrogen in its hydrogen related projects: (Res. G-3601, O.P. 3.a and O.P.3.b)

- Renewable Gas Production
- Environmental & Safety
- Operations Technology
- System Inspection & Monitoring
- Integrations & Controls
- Advanced Innovation
- Commercial Applications
- Commercial Food Service

In compliance with OP 3c, SoCalGas remains committed with the State's clean renewable hydrogen (CRH) vision and supports the overall direction the Commission is taking in G-3601 regarding the utilization of CRH in SoCalGas's research projects. SoCalGas understands that requiring CRH be used in hydrogen gas research and development approved by the Commission to be a novel requirement. Therefore, for active research projects that utilize hydrogen, SoCalGas will review the sources of gases used for each one to determine if the source complies with the definition of CRH. If it is concluded the hydrogen used does not fit the definition of CRH, SoCalGas will evaluate the feasibility of procuring CRH for the project at the volumes required. For projects where no options are feasible, next steps may include termination of contracts and reallocation of funds to an approved subprogram or suspension of contracts until an alternative solution is identified. As part of this evaluation, SoCalGas plans to share the findings, including market participants, quantities available to purchase, source and location of CRH, price, carbon intensity, purity, certification process, and estimated transportation costs, with Energy Division. These findings will help SoCalGas, the Energy Division, and research partners better understand the market for CRH, including the commercial arrangements needed to both procure CRH to comply with this requirement.

Res. G-3601 denied funding towards hydrogen blending projects in the System Design and Materials subprogram (Res. G-3601, O.P. 3.a). SoCalGas RD&D has three hydrogen blending projects under the System Design and Materials subprogram that are industry collaborative programs with many funders in which all project funds for these projects have been expended in 2023 prior to Res. G-3601 issuance as authorized by Res. G-3586 for multi-year projects and have completion dates in 2024. Therefore, no reallocation of funds is possible and rate-payer benefits, including benefits beyond the hydrogen blending scope are expected to be achieved at project completion. These projects are designated in Appendix E under "Hydrogen Blending Projects", column V.

Resolution G-3601 denied SoCalGas RD&D proposed allocation for the following subprograms: (Res. G-3601, O.P. 3.a)

- CCUS
- Off-Road
- Onboard Storage
- On-Road
- Refueling Stations
- Residential Appliances

Subprograms that were denied by the Commission are all being retired in the Revised 2023 RD&D Research Plan. A subprogram that is being retired has costs associated with retirement. The costs for retired subprograms are reflected in the revised RD&D funding allocation and include financial obligations incurred in 2023 up to Res. G-3601 issuance for activities related to multi-year agreements executed in 2022 or before, as authorized by Res. G-3586[19] . These obligations are divided into two categories: (1) Actual Incurred Costs, and (2) Estimated Incurred Costs. Additional information for costs associated with retired subprograms is shown in the revised Attachment B for each project. SoCalGas submits that this treatment is consistent with the precedent set by the Commission in the Senate Bill (SB) 1371 Bi-annual Leak Abatement proceeding. In that case, the Commission authorized recovery of costs SoCalGas recorded, in good faith and pursuant to preliminary guidance from Safety Enforcement Division (SED), while awaiting final resolution from the Commission.

Res. G-3601 allowed the continuation of in-progress projects and denied the proposed allocation for new projects in the Distributed Generation and Industrial Process Heat subprograms (Res. G-3601, O.P. 3.a and O.P. 7). SoCalGas appreciates the opportunity given by the Commission to continue the contracted projects under the Distributed Generation and Industrial Process subprograms. SoCalGas is retiring these two subprograms and is presenting in its revised 2023 RD&D Research Plan expenses for completing in-progress projects only. The list of in-progress projects has been updated to reflect agreements executed in 2022, Including the ones contracted between the submission of SoCalGas AL 5991-G and the end of the 2022.

Res. G-3601 also directed SoCalGas to reallocate funding allocations from denied subprograms into activities -, such as a comprehensive RD&D program evaluation and a comprehensive Gas RD&D database. It also directed SoCalGas to consider reallocate funds towards research involving pipeline and system integrity, gas decommissioning, and cybersecurity. (Res. G-3601, O.P. 3.a)

In its revised 2023 RD&D funding allocation, SoCalGas is reallocating funds from denied subprograms towards a comprehensive RD&D program evaluation ($675,000) and a comprehensive Gas RD&D database ($129,938), as directed by Res. G-3601.

SoCalGas RD&D is committed to developing and proposing new RD&D projects and reallocating funds towards initiatives that directly benefit gas ratepayers, including those research areas approved by Res. G-3601. Accordingly, we will continue to pursue new and innovative research areas, including those mentioned in the Resolution such as gas system decommissioning, system integrity and cybersecurity. Care will be taken to make sure research undertaken in these areas will add to ongoing research and policymaking activities. For instance, new RD&D projects in the Gas Decommissioning research area

[19] Res. G-3586 at page 7.

will draw guidance from the Long-term Gas System Planning OIR (R.20-01-007),[20] as well as attempt to build off other relevant research, such as that funded by the CEC under PIR-20-008, September 2023.

In response to the Resolution, SoCalGas is proposing an initial provisional funding allocation to these new areas to support research that may be practical to accomplish in this funding cycle. A more comprehensive review of research needs will be performed to further develop these subprograms and inform appropriate scope and budget for each initiative in the future. In its revised 2023 RD&D Research Plan SoCalGas is increasing the allocation of funds towards the System Design & Materials subprogram by $250,000 to increase the number or scope of projects in the pipeline and system integrity area. The Environmental and Safety subprogram allocation proposal was increased by $250,000 to budget for projects associated with gas system decommissioning. The Operations Technology subprogram funding allocation was also increased by $250,000 to budget for cybersecurity research projects. The Integration and Controls subprogram also received an additional $250,000 in reallocated funds to further develop cybersecurity related research projects.

6.2 Funding Allocations by Research Consortium

Per Resolution G-3586, SoCalGas RD&D is instructed to:

> *Provide detail quantifying research funding allocations by research consortium, as well as project costs related to each consortium.*

The breakdown for each Research Consortium dues is listed in the table below. Consortium dues in total represent approximately 10% of total combined project costs.

Research Consortium	2023 Dues		
	Total	**Portion for Administration**	**Portion Allocated to RD&D Projects**
NYSEARCH	$72,250[(a)]	$72,250	$0
OTD	$750,000[(b)]	$60,000	$690,000
PRCI	$150,000[(c)]	$50,000	$100,000
UTD	$350,000[(d)]	$35,000	$315,000

[(a)]NYSEARCH dues estimate based upon dues history. Membership comprises 25 regulated gas utilities[21]

[(b)]OTD dues estimate: The dues total is based upon the SoCalGas number of meters with the maximum dues amount of $750,000. OTD dues are offset by projects funded under the SB1371 Leakage Abatement program. Membership comprises 29 natural gas distribution companies[22].

[(c)]PRCI dues estimate: PRCI dues are calculated annually based upon miles of pipe as reported to DOT the preceding year. PRCI membership includes 60 companies who are operating natural gas transmission and crude oil and petroleum products pipelines and other organizations and service providers supporting the industry[23].

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[20] See R.20-01-07 February 22, 2024 Assigned Commissioner's Ruling Scheduling Phase 3 Prehearing Conference and Providing Joint Agency Staff Gas Transition White Paper and Draft Phase 3 Scope and Schedule for Party Comment, Attachment A.
[21] https://www.nysearch.org/about.php#membership
[22] https://www.otd.org/
[23] https://www.prci.org/Membership/2928.aspx

(d)UTD dues estimate: The dues are based upon the SoCalGas number of meters with the maximum dues amount of $350,000. UTD membership composed of 20 natural gas distribution companies[24]. Note: SoCalGas RD&D will not fund membership in UTD. after 2023.

The total consortium-related project costs in the table below include 2023 "continuing projects" (projects previously initiated and spanning multiple years) based upon estimated end dates as of December 31, 2022.[25] The leverage ratio shows the research value proposition for every dollar SoCalGas funds. For example, a leverage ratio of 32.67x for $1.5m of funding gives $50.5m worth of research. More details on continuing projects can be found in Appendix E - Project Details.

Research Consortium	**RD&D Project Funding by Consortium**		
	Total SoCalGas Funding	**Total Project Funding**	**Total Leverage Ratio - Project**
NYSEARCH	$753,397	$9,872,862	13.1x
OTD	$2,587,968	$24,689,727	9.6x
PRCI	$1,781,309	$32,351,524	18.2x
UTD	$915,022	$12,781,327	14x
All Consortiums	$6,037,696	$79,695,440	13.2x

SoCalGas RD&D has identified six ratepayer benefits to align with subprograms and their projects: safety, reliability, operational efficiency, improved affordability, reduced GHG emissions, and improved local air quality.[26] These benefits are reviewed along with other criteria when SoCalGas selects consortium projects to fund.[27] The following illustrative pie charts show generally the distribution of projects delivering each benefit, by consortium.

[24] https://www.utd-co.org/wp-content/uploads/2021/09/UTD-Prospectus-Sept2021.pdf
[25] Advice Letter 5991 Total project cost was based upon 2023 continuing projects as of 5/1/2022.
[26] 2022 SCG RD&D Annual Report, page 8: Project Benefits
[27] Appendix D: Project Selection Process

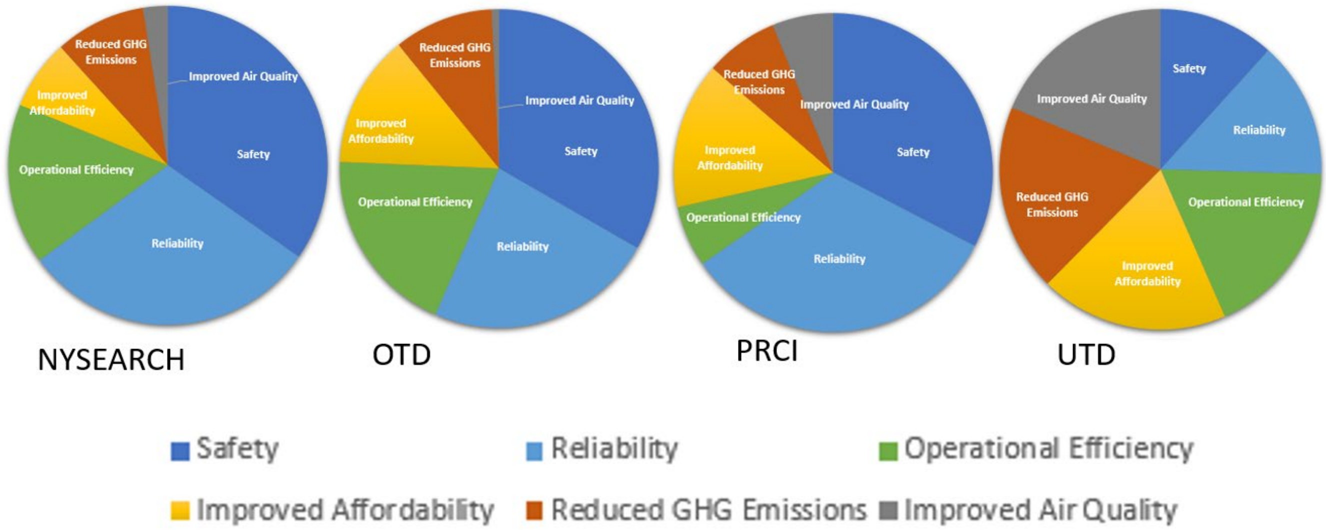

Figure 1-1: Percentages of projects delivering each ratepayer benefit by consortium

The utilization of consortium dues varies by organization. Dues cover administrative expenses, with the remaining portion allocated directly to SoCalGas-initiated or selected projects.

As demonstrated by the tables above, the majority of consortium spend and membership dues are allocated to R&D projects that are either initiated by or specifically selected for funding by SoCalGas. The subcategory of funds only allocated to administrative expenses are justified by direct ratepayer benefits by many aspects of the programs. Participation in the research consortiums facilitates collaboration and knowledge sharing between SMEs from other natural gas system operators and industry RD&D program and project managers. Research consortiums generally provide members the opportunity to learn about and discuss emerging operational and utilization issues and needs within the industry, both nationally and internationally.

The ratepayer value of such collaboration includes:

1. Provide subject matter experts a forum for learning and gaining operational insights regarding differences in pipeline system materials and equipment, operating environments, operational experiences, procedures, and practices;
2. Operational knowledge that may only apply to a small subset of system assets or operational conditions;
3. Knowledge sharing of pipeline incidents, causes or insights on interactive threats with very low probability of occurrence but high consequence;
4. Knowledge sharing between large and small system operators that can provide a positive effect on the performance of the overall natural gas supply chain,
5. Knowledge of emerging areas of research or technologies that could be utilized by SoCalGas to support operational efficiency, pipeline safety, system reliability, and environmental improvement.

Consortium membership leverage administration expenses related to the bidding process and management of large National and State research projects funded by the DOE, PHMSA and CEC. Membership also leverages existing relationships with federal and state regulators, industry, national laboratories, and academic institutions, which also can be related to the leverage of administrative costs of the program. For regulated utilities, it is challenging to develop in-house expertise in technology transfer as it is a lengthy, complicated process. In addition, consortiums use specialized resources that are dedicated to RD&D assignments that typically span many years of development. Managing intellectual property (IP) and licensing is a specific skill set that is typically more cost-effectively managed by consortiums, since RD&D is typically performed by innovators and/or companies who do not have the necessary industry expertise and specialty resources.

Consortium membership also provides SMEs and company employees with access to literature repositories to research relevant information that would otherwise either not be available or need to be purchased regardless if SoCalGas funded the research. Examples of the benefits of this information include: provides centralized banks of information for literature review; access to knowledge that could pertain to new regulations on the horizon or supporting new company initiatives; ability to leverage previous work to support implementation of large-scale projects, or to address potential safety and integrity issues identified by other utilities. For example, when PHMSA issued the Notice of Proposed Rule Making in 2016 for the Mega Rule pertaining to the safety of onshore gas transmission pipelines, SoCalGas used the consortium historical research to determine where further research was needed to meet the forthcoming requirements supporting operations and integrity management.

The RD&D projects funded within each consortium stand on their own merits regarding ratepayer benefits; however, following is a list of additional potential ratepayer benefits:

1. For a technology or tool to evolve and advance within Technology Readiness Levels (TRL)[28] it must withstand various operational challenges and impacts that cannot show themselves until later stages of product development or in early customer adoption trials. With R&D consortiums more companies are involved in piloting the technology or service in pre-commercial demonstrations or testing in a wider range of commercial and operational conditions than individual operators can typically achieve.
2. R&D Consortiums are better positioned to identify and develop potential commercial partners who must be convinced to take the business risk and accept innovations developed from consortium projects by providing prospective manufacturers or service providers more market potential because of the larger number of customers that it represents throughout the country, continent or globally.
3. R&D consortiums can provide commercial partners with insight into broader industry needs to set market expectations and input on metrics for success.
4. R&D consortiums can provide more expedient commercialization and implementation of technologies available for the natural gas industry.
5. R&D consortiums have experience and visibility with government agencies especially with their research funding opportunities and solicitations.

[28] TRL is a metric used for describing technology maturity. More information at https://www.directives.doe.gov/terms_definitions/technology-readiness-level

Endorsement by federal agencies for funding research to support proposed regulatory requirements or regional considerations. Successful technology transfer often comes from external drivers such as commercialization incentives, state-level regulatory drivers or other means for encouraging ‘early adopters’ of new technology.

6. R&D consortiums typically have dedicated technical managers working on behalf of multiple industry customers with consensus-based specifications that are tested against commercial requirements.

The following are some examples of successful research performed by research consortiums that SoCalGas funded.

NYSEARCH – In-Line Inspection Technologies RD&D

The Explorer series of robotics inspection platforms is a wide range of technologies developed by the NYSEARCH consortium to address issues related to pipeline integrity, specifically the inspection of non-piggable pipe. The research started in 2003 with SoCalGas joining as a funder in 2004. The Explorer became commercially available with corrosion detection and mechanical damage sensing capabilities in 2011 when SoCalGas demonstrated the Explorer 10/14 MFL platform. NYSEARCH and its members then initiated subsequent development to add sensing and operational capabilities to increase Explorer’s efficacy, effectiveness and productivity. Recently completed research worked to expand the crack sensing capabilities. This project was featured in an RD&D webinar mid-2023.[29] Other efforts are underway to extend the inspection range, reducing the number of launch points necessary to perform an inspection.[30] SoCalGas ratepayers benefit by the technology, prioritized by project funders, reaching commercialization more quickly. The SoCalGas Integrity Management Program utilizes the existing robotic inspection platform, and has identified a list of improvements to meet future needs including improved crack detection sensitivity for tighter cracks, and the ability to handle the presence of liquids and debris to reduce the need to stop inspections to clean the line.

OTD - Cross-bore Technologies RD&D

In 2010 a house explosion occurred in St. Paul, Minnesota. The cause was determined to be an incident where a gas line was directionally drilled through a sewer line, commonly referred to as a “cross-bore”. This event prompted new research to develop tools and methodologies to inspect for, detect, mitigate, and prevent cross-bores to address this potentially high-consequence threat. SoCalGas joined with other utilities in the Operations Technology Development consortium to fund research which resulted in detection tools and best practices. This work formed the foundation of the current SoCalGas “Sewer Lateral Inspection Program” that works to find and mitigate existing cross-bores and prevent future incidents from occurring. Research was also performed to develop technology to detect obstacles in advance of horizontal directional drilling (HDD) operations. This is an example, where SoCalGas and its ratepayers benefited from the experiences of other utilities and participation in a R&D consortium. SoCalGas is

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[29] Explore Robot – Seam Weld Crack Sensor (M2016-004 Ph IV) https://youtu.be/qcJSjGZ3xrY

[30] Extending Energy Harvesting to Other Explorer Sizes - A Feasibility Study (M2021-011), Explorer Wireless Range Extender (M2021-006)

currently funding research to advance the HDD forward sensing capabilities[31] and to determine the parameters where high-pressure water jets damage plastic pipe[32]. SoCalGas anticipates incorporating the project results into existing programs and outreach materials for contractors making them aware of these potential hazards.

PRCI – System Design & Materials Research

In response to safety advisories from Pipeline and Hazardous Material Safety Administration and the Canada Energy Regulator, Pipeline Research Council International (PRCI) started research to find a solution to prevent girth weld failures of newly constructed pipelines in-service or during construction hydrostatic leak testing[33]. The essential goal was to prevent similar girth weld incidents from happening in both in-service pipelines and pipelines to be built in the future. Historically, girth weld failures have been a very small portion of pipeline incidents. However, at least 30 incidents have occurred world-wide indicating that this is not a one-of-a-kind event. The PRCI project reviewed available incident information determining that weld strength undermatching, heat-affected zone softening, and elevated loads were the main factors in causing the girth weld failures. The project deliverables included recommendations and guidance to improve industry practice and support potential updates to standards and design specifications. This project is an example where SoCalGas collaborated with industry experts to develop technical solutions to prevent incidents that could impact safety and system reliability for SoCalGas ratepayers.

UTD – High Efficiency Smart Convection Oven

The objective of this project is to develop a prototype high-efficiency smart convection oven that increases efficiency by at least 5% and integrates smart operating controls to maximize food preparation quality and consistency. Previously, researchers investigated a high-efficiency oven design, showing that this configuration in bench-scale tests achieved a 3% improvement in cooking efficiency and a 10% improvement to preheat energy use despite needing to be fully optimized. Based on these results and improvement areas in the initial design, the project team anticipates a 5%-10% increase in cooking efficiency should be achievable once they optimize the system. In addition, the team expects a targeted 10%-20% reduction in NOx and carbon monoxide emissions. In this project, researchers are incorporating a heat exchanger to recover heat from the flue and feed it back into the combustion air. In 2021, the project team completed basic testing on the modified heat exchanger. Researchers specified and ordered a new prototype burner with a premix system. The project team installed the new burner in the oven and completed some initial testing. The group modified the oven to mount the new burner instead of the existing burner. In 2022, additional testing and modification were underway. Discussions with a leading manufacturer continue regarding commercialization opportunities and other next steps to make this more efficient oven available to end users.

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[31] ORFEUS Obstacle Detection Technology for Horizontal Directional Drilling (5.16.k.2)
[32] Plastic Gas Pipe Damage Assessment due to high pressure water jets and cross bores (5.23.g)
[33] https://www.prci.org/Research/DesignMaterialsConstruction/DMCProjects/MATH-5-3B/101449/249051.aspx

7 LOW CARBON RESOURCES

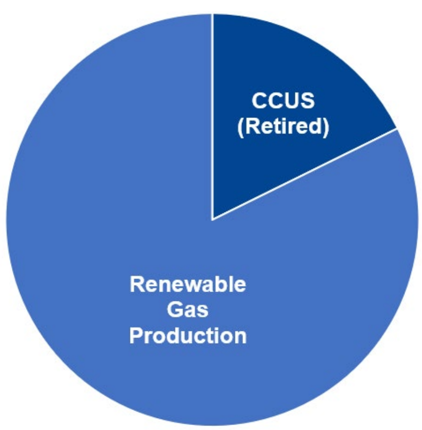
The primary goal of the Low Carbon Resources program area is to decarbonize the gas supply while maintaining its affordability and reliability. To achieve this goal, program staff members develop, promote, and advance new technologies aimed at increasing and expanding the production and use of hydrogen and renewable natural gas (RNG), displacing conventionally sourced pipeline gas, and capturing and permanently removing atmospheric GHG emissions. RD&D Program personnel in the Low Carbon Resources program area focus their efforts on the following goals:

- Increasing the availability of renewable gas and promoting pipeline decarbonization solutions by advancing production technologies that diversify renewable gas feedstocks and pathways.
- Offsetting emissions from conventional natural gas use by capturing and permanently removing atmospheric GHG emissions through carbon capture utilization and sequestration (CCUS) technologies.

7.1 Proposed 2023 Low Carbon Resources Funding Allocation

<u>Revisions pursuant to Res. G-3601:</u>

SoCalGas is retiring the CCUS subprogram in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for CCUS includes SoCalGas' existing contractual obligations prior to the issuance of Res. G-3601.



Subprogram	Original Allocation	Revised Allocation
CCUS (Retired)	50%	18%
Renewable Gas Production	50%	82%
Total	**$5,619,042**	**$4,777,158**

Figure 2: Summary of proposed 2023 Funding Allocations for Subprograms within the Low Carbon Resources Program.

7.2 Carbon Capture, Utilization, and Sequestration (Retired)

7.2.1 Subprogram Overview

This subprogram focuses on carbon capture, utilization, and sequestration—all vital in the fight against climate change. Roughly half of the excess CO_2 released into the atmosphere by human activity is absorbed by plants and the world's oceans. CCUS technologies seek to capture, utilize, or sequester the balance of these CO_2 emissions through a variety of approaches, including direct air capture coupled with either conversion into plastics, cement, and biofuels (carbon capture utilization or CCU) or sequestration into depleted oil fields and saline aquifers (carbon capture sequestration or CCS). This subprogram's portfolio also includes methane pyrolysis projects in which solid carbon is produced from a methane feedstock and captured simultaneously with hydrogen generation. However, because the carbon produced can either be converted into a useful product or sequestered in solid form, methane pyrolysis will be listed as a stand-alone category under CCUS.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the CCUS subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 7.2.6.

7.2.2 Policy Considerations

Carbon capture can help California reach its ambitious decarbonization and climate change mitigation goals more expeditiously by not only offsetting emissions from various GHG-emitting sectors, but also by creating a circular and carbon-negative economy. This subprogram can impact public policy by providing a realistic pathway for California to reach its carbon neutrality goals by 2045. The report *Getting to Neutral*, published by the Lawrence Livermore National Laboratory, indicates that California needs to remove 125 metric tons of CO_2 per year by 2045 to achieve state carbon neutrality goals. In addition, simultaneous carbon capture and hydrogen production pathways, such as biomass gasification with CCUS or methane pyrolysis, can make large-scale carbon removal solutions cost-effective in California. CCUS can support various California policies and regulations.

Policy	Description
AB 3232	Building decarbonization
EO B-55-18	2045 Carbon-neutral California economy
Clean Air Act	Air quality standards for NOx and PM
LCFS	Reduce carbon intensity of transportation fuels
AB 8	Development of 100 hydrogen refueling in California
EO B48-18	200 hydrogen refueling stations in California by 2025

7.2.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Carbon Capture**
  Carbon capture explores different carbon capture pathways, techniques, and methodologies. Carbon capture technologies under consideration in this area aim to investigate and improve various CO_2 extraction and capture technologies while meeting cost and efficiency constraints needed for mass deployment. For example, CO_2 could be captured from biogenic point sources to enhance RNG yield and recovery from biodigesters, from industrial point sources to prevent release of CO_2-laden flue gas to the atmosphere, from atmospheric sources via

direct air capture, and from oceanic carbon sources via CO_2 bipolar membrane electrodialyzers. All these technologies are at different stages of development and could revolutionize SoCalGas' ability to offset carbon emissions post-release.

- **Area 2: Carbon Utilization and Sequestration**
  Carbon utilization encompasses a wide variety of conversion technologies through which CO_2 is converted into valuable chemicals, including methanol, plastics, dimethyl ether (DME), concrete, and biofuels such as RNG. Several technologies and processes can be leveraged to convert CO_2 into useful products, including:
    - Electrochemical and electrocatalytic processes, such as, plastics and biofuels production from CO_2 and water using electricity
    - Electro-methanogenesis, that is, RNG production from CO_2 and water using electricity
    - Mineralization processes, such as concrete production

  Alternatively, CCS involves the use of geological formations, such as active or depleted oil and gas reservoirs, as well as saline aquifers in the San Joaquin Valley to sequester CO_2. Studies by the Intergovernmental Panel on Climate Change (IPCC)[34] and the California Council on Science and Technology (CCST) have shown that CCS has the potential to reduce carbon emissions by billions of metric tons and may be an integral part of meeting California's climate goals in 2050.[35] Indeed, CCS allows for existing fossil fuel resources, such as natural gas, to be used in a way that produces far fewer carbon emissions than their use without CCS. Due to the potential importance of CCS in meeting California's long-term climate goals, CARB plans to integrate CCS into its climate programs in compliance with the AB 32 requirements that GHG emissions reductions achieved are real, permanent, quantifiable, verifiable, and enforceable. Studies have concluded that there is sufficient pore space available in California to inject tens of billions of metric tons of CO_2. CCS is already being deployed to sequester carbon emission from large-scale steam methane reforming (SMR) facilities and improve the carbon intensity of natural-gas-derived hydrogen. Projects in this research area aim at identifying and demonstrating the most economically viable CCS pathways, including co-generation of hydrogen and electricity. In addition, synergies can also exist between CCS technologies and various renewable gas production pathways, such as biomass gasification.
- **Area 3**: **Emissions-Free Hydrogen Production via Methane Pyrolysis**
  SoCalGas is investigating multiple methane pyrolysis pathways. Methane pyrolysis is a nascent but extremely interesting technology that consists of bubbling methane into a molten solution to decompose it into hydrogen and solid elemental carbon. The carbon can be used for a wide variety of applications, such as cement additives and carbon nanotubes. This technology has tremendous decarbonization potential because it does not generate any carbon emissions and can therefore reduce the cost of large-scale hydrogen generation while simultaneously offsetting carbon emissions.

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[34] IPCC, 2014, Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, page 151.
[35] CCST, 2011, California's Energy Future: The View to 2050.

7.2.4 Subprogram Benefits

Benefit	Explanation
Reliability	Leveraging synergies between renewable energy surplus/curtailment, carbon capture, and RNG production from captured CO_2 through advanced methanation processes can help improve gas system reliability and reduce reliance on out-of-state gas resources while simultaneously decarbonizing the pipeline. This benefit relates to the identical benefit under the "Renewable Gas Production" subprogram.
Environmental: Reduced GHG Emissions	CCUS systems can permanently remove CO_2 from the air, resulting in potentially negative overall carbon emissions. In addition, emissions-free hydrogen production via methane pyrolysis can further help decarbonize the pipeline and reduce its associated GHG emissions as well as offset emissions from hard-to-decarbonize industrial sectors.
Environmental: Improved Air Quality	Hydrogen produced from methane pyrolysis can improve air quality.

7.2.5 Equity Considerations

CPUC ESJ ACTION PLAN GOAL 2

Increases investment in clean energy resources to benefit ESJ communities, especially to improve local air quality and public health.

Deployment of carbon capture technologies near industrial facilities, most of which are co-located in ESJ communities, can improve the air quality in those communities. In addition, hydrogen from methane pyrolysis can be used directly to provide emissions-free energy in hard-to-decarbonize industries, such as steel and aluminum, which are also located in ESJ communities. These benefits to ESJ communities are in line with Goal 2 of the CPUC ESJ Action Plan. Equally as important, by offsetting GHG emissions, CCS technologies will reduce the negative impact of climate change on ESJ communities (Section 4.1).

7.2.6 Revised Funding Table

<u>Revisions pursuant to Res. G-3601:</u>

Low Carbon Resources Program Carbon Capture, Utilization & Sequestration Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$615,000	-
Actual Incurred Cost Jan-Nov 2023	-	$ 816,567
Funds for Project Under Development for 2023	$2,194,521	$0
Estimated Incurred Cost Jan-Nov 2023[a]	-	$28,987
Total Sub-program Funding for 2023	$2,809,521	$845,553
Funds Available for Reallocation	-	$1,963,968
Sub-program Percentage of Funding	50%	18%

[a] Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

7.3 Renewable Gas Production

7.3.1 Subprogram Overview

This subprogram focuses on the safe, reliable, and cost-effective production of renewable gaseous fuels—specifically RNG and hydrogen—from various feedstocks and multiple technological pathways.

7.3.2 Policy Considerations

Renewable gas production aligns and conforms with California's decarbonization goals through its direct relevance and applicability to several key policies. By reducing the carbon intensity of the gas grid through its gradual decarbonization, this subprogram supports the following policies:

Policy	Description
AB 3232	Building decarbonization
EO B-55-18	2045 Carbon-neutral California economy
Clean Air Act	Air quality standards for NOx and PM
SB 32	Regulating and monitoring GHG emission sources
AB 32	GHG emission reduction targets
SB 1383	Methane (CH_4) emissions from organic waste
LCFS	Reduce carbon intensity of transportation fuels
AB 8	Development of 100 hydrogen refueling stations in California
EO B48-18	200 hydrogen refueling stations in California by 2025

7.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Renewable Hydrogen Production via Advanced Water-Splitting**
  Direct, high-efficiency sunlight/photon-driven water splitting into hydrogen and oxygen is an important research area with tremendous potential to streamline the conventional, multi-step water electrolysis process by coupling renewable electric power and water electrolysis into a one-step hydrogen-producing process. By decoupling green hydrogen production from the power grid, this technology would also eliminate intrinsic power system conversion and transmission losses, costly transmission system upgrades, and competition with electricity end users. In addition, the Low Carbon Resources Program area is also exploring ways to reduce conventional electrolysis cost and improve its efficiency by relying on earth-abundant catalysts and exploring pathways to reduce the operating cost burden imposed through electric T&D costs.
- **Area 2: Renewable Methane Production via Various Methanation Pathways**
  Renewable methane production from biogenic CO_2 with methanation—via conventional thermo-catalytic methanation, electrocatalytic processes, or the use of biological methanogens—is a key area of research that can be broadly deployed to capture and convert biogenic CO_2 emissions from bio-digesters, ethanol plants, landfills, and biomass gasifiers into RNG. Therefore, methanation technologies can expand the availability of renewable gas and avoid the

upstream production, gathering, storage, transportation, and end-use GHG emissions associated with fossil-sourced gas; reduce net emissions; and improve air quality. Moreover, RNG produced via methanation has approximately triple the energy density of hydrogen (approximately 990 British thermal units per standard cubic foot [Btu/scf] versus 330 Btu/scf) and, most importantly, can be directly injected into the existing gas grid without the need for any system retrofit or modification.

- **Area 3: Renewable Gas Production via Biomass Gasification**
  Biomass is an abundant domestic resource that literally "recycles" CO_2. California has tremendous biomass resources that can be leveraged to not only produce renewable energy, but also mitigate the effects of devastating fires, which release very large quantities of GHG and criteria pollutants. Biomass gasification uses a controlled process involving heat, steam, and oxygen to convert biomass to hydrogen, RNG, and other products without combustion. Because growing biomass removes CO_2 from the atmosphere, the net carbon emissions of this method can be low, or even negative, especially if coupled with CCUS in the long term. Key challenges to hydrogen production via biomass gasification involve reducing costs associated with capital equipment and procuring continuous biomass feedstocks.
- **Area 4: Distributed Hydrogen Production via Advanced Steam Methane Reforming of Biomethane**
  SoCalGas is exploring different SMR technologies, including advanced catalytic non-thermal plasma (CNTP) and 3-D printed meso- and micro-channel SMR reactors. SMR technology has progressed greatly in recent years with the development and manufacturing of a new, high-efficiency, low-cost, modular, combustion-free, solar- and/or induction-heat-driven, SMR technology for distributed hydrogen production. Originally developed by PNNL and being commercialized by STARS corporation, this technology has now reached a high technology readiness level (TRL) and is being deployed for field demonstration to support distributed hydrogen production. Incidentally, the first-ever production of oxygen on Mars was recently achieved by MOXIE (Mars Oxygen In-situ utilization Experiment) onboard the NASA Mars2020 using similar 3-D printed microchannel heat exchanger technology, originally developed by PNNL, and now used in the STARS SMR reactor, which is licensed to SoCalGas.
- **Area 5: Concentrated Solar Power Technology for Renewable Gas Production**
  Concentrated solar power (CSP) technology can be leveraged to drive renewable gas production through seamless integration with biomass conversion processes to further reduce the carbon intensity of biomass-derived renewable gas, increase system efficiencies, and improve overall performance.

7.3.4 Subprogram Benefits

Benefit	Explanation
Reliability	Broadly, the gas grid can improve energy reliability by absorbing curtailed power and synchronizing renewable energy supply with demand by storing energy in the form of RNG/hydrogen and shifting utilization across days, weeks, and months. Specifically, surplus renewable energy from wind, solar, and organic wastes can be channeled to make hydrogen for pipeline injection and long-duration

	energy storage. Alternatively, renewable hydrogen can be processed with biogenic CO_2 emissions to produce RNG via methanation processes. In 2020, up to 1,586,500 megawatt hours of electricity were curtailed in California according to the California Independent System Operator. This translates to approximately 32,000 metric tons of hydrogen production from electrolysis and, correspondingly, 168,000 metric tons of CO_2 that potentially could have been recycled to methane from methanation pathways. In addition, hydrogen and RNG can be produced from biomass—a clean, reliable, locally available energy resource.
Safety	The latest hydrogen high-pressure tube trailer storage technology can allow the transport of 560–720 kilograms for on-road vehicles. Distributed hydrogen generation of similar capacity located at end-user sites and closely matching production to end-user demand eliminates the need for hydrogen transportation from centralized production points in high-pressure containers and large quantities of end-user storage, making hydrogen adoption inherently safer. In addition, small, modular on-site hydrogen generation systems contain relatively small amounts of hydrogen and can more easily be turned off should a plant upset occur.
Improved Affordability	The development of technologies and innovations for renewable gas production at the lowest possible cost would result in increased affordability and accessibility of renewable gas to ratepayers. Critically, a hydrogen production target price of $2 per kilogram by 2030 would allow hydrogen to become a cost-effective consumer alternative to conventional fuels.
Environmental: Reduced GHG Emissions	Hydrogen and RNG production can displace fossil-sourced hydrocarbons, thereby reducing, mitigating, or eliminating associated CO_2 and methane emissions. Carbon-negative hydrogen production cycles are now being deployed that directly remove CO_2 from the atmosphere.
Environmental: Improved Air Quality	Replacement of fossil-sourced gas with renewable hydrogen can improve air quality, especially in industrial zones, by facilitating the transition from conventional combustion technologies to electro- and thermo-catalytic processes that eliminate NO_x and PM emissions.

7.3.5 Equity Considerations

By decarbonizing the pipeline and replacing its fossil-sourced content with renewable gas, this subprogram seeks to reduce emissions and improve air quality in areas neighboring industrial facilities, most of which fall within ESJ Communities. This work is in direct alignment with Goal 2 of CPUC's ESJ Action Plan: "Increase investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health." Equally as important, by reducing GHG emissions, the development and deployment of zero-emission transportation fuels will reduce the negative impact of climate change on ESJ communities (Section 4.1).

7.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Low Carbon Resources Program Renewable Gas Production Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$0	-
Actual Incurred Cost Jan-Nov 2023	-	$862,535
Funds for Project Under Development for 2023	$2,809,521	$1,946,986
Reallocated Funds from Available Funding	-	$1,122,084
Total Sub-program Funding for 2023	$2,809,521	$3,931,605
Sub-program Percentage of Funding	50%	82%

SoCalGas is proposing to reallocate a portion of the available funds to the Renewable Gas Production subprogram, in part, to enable new and existing projects to meet the requirements for utilization of clean renewable hydrogen. This will also provide additional ratepayer benefits as utilization of clean renewable hydrogen will result in reduced GHG emissions and improved air quality. Funding additional projects in the Renewable Gas Production subprogram will help accelerate development and de-risk clean energy technologies, such as water electrolysis for hydrogen production. These projects can provide ratepayer benefits by helping to reduce costs and improve affordability of clean renewable fuels.

As clean technologies in the Renewable Gas Production subprogram advance via demonstration projects, additional funds will be needed to accommodate increased research costs that will arise from developing these demonstrations. These additional costs include the necessary construction costs to adapt host sites to the requirements of the technology demonstration project. Moreover, SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline, allowing these additional funds to be prudently and expeditiously deployed towards projects that can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

8 GAS OPERATIONS

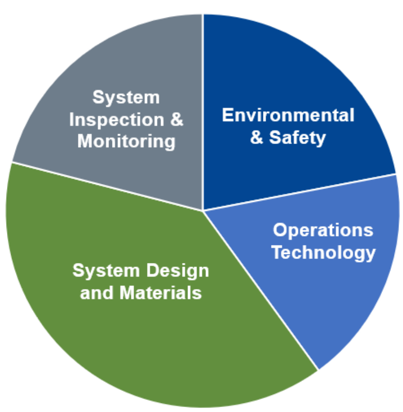
The Gas Operations Program area supports pipeline and storage operations through innovations that enhance public and employee safety, maintain system reliability, increase operational efficiency, and minimize GHG and operational impacts to the environment. The program also facilitates technology development driven by emerging regulatory requirements. Its primary goal is to develop, test, and introduce new gas operations technologies that are beneficial to ratepayers, public safety, and the environment.

More broadly, the objectives of the Gas Operations Program area are to:

- Improve gas safety and system integrity
- Improve or enhance system reliability
- Advance system design and materials
- Increase operational efficiencies and effectiveness
- Reduce system emissions

The program invests in technology development projects in the following subprograms: 1) Environmental & Safety, 2) Operations Technology, 3) System Design & Materials, and 4) System Inspection & Monitoring.

8.1 Proposed 2023 Gas Operations Funding Allocation



Subprogram	Original Allocation	Revised Allocation
Environmental & Safety	20%	22%
Operations Technology	15%	18%
System Design and Materials	40%	39%
System Inspection & Monitoring	25%	21%
Total	**$3,644,784**	**$4,394,784**

Figure 3: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Gas Operations Program.

8.2 Program Benefits

Projects supported by the Gas Operations Program area deliver a wide range of benefits.

Benefit	Explanation
Reliability	Projects in this program focus on developing methods and technologies for more effective pipeline construction, alteration, and repair and on minimizing impacts to the public through avoidance of service

	interruptions and construction disruptions by extending the service life of the pipeline infrastructure.
Safety	Projects in this program seek to develop advanced systems to identify and mitigate threats to the pipeline system, protect pipelines from intentional and unintentional damage, and focus on various other aspects related to the safety of the public, company employees, and contractors working on or around the pipeline and system facilities.
Operational Efficiency	Projects in this program seek to identify practices that streamline processes, reduce time-on-task, leverage automation of data gathering and analytics, improve effectiveness, and develop new technologies to advance pipeline safety and regulatory compliance. Examples of such projects include developing less-invasive pipeline construction methods or more efficient operation and maintenance methods.
Improved Affordability	Projects in this program seek to drive development of technologies and innovations that reduce or avoid operational costs to increase energy affordability for ratepayers.
Environmental: Reduced GHG Emissions	Projects in this program develop technologies and best practices for reducing GHG emissions and mitigating the impacts of gas system emissions on climate change.
Environmental: Improved Air Quality	Projects in this program reduce the environmental impact of the pipeline system emissions through reducing the emissions of harmful air pollutants, such as post-combustion criteria pollutants.

8.2.1 Equity Considerations

The natural gas pipeline system serves customers regardless of their socioeconomic status. The Gas Operations Program funds a wide variety of projects applicable to all aspects of system pipeline operations. Many of this program's projects improve the efficiency of the gas pipeline and therefore its affordability. This keeps energy costs more affordable, which has a greater positive impact on ESJ community members, for which energy costs may comprise a greater share of their incomes. Importantly, many of the innovations developed by this program are adopted nationally by other utilities, which supports equity across the nation.

8.3 Environmental & Safety

8.3.1 Subprogram Overview

This subprogram seeks to advance the environmental integrity of the pipeline network and the safety of those who live and work in proximity to it. Environmental projects focus on developing technologies that also support state goals. Safety projects are concerned with protecting the pipeline from intentional and unintentional damage and improving the safety of the general public and company employees or contractors working on or around the pipeline. Projects include exploring how blending hydrogen into the pipeline impacts the operation and maintenance of the pipeline system regarding safety, reliability, integrity, and environmental impacts.

Furthermore, gas emissions monitoring and reduction research is being supported by the SoCalGas Natural Gas Leakage Abatement R&D Program under the SB 1371 compliance plan, pursuant to the Gas Leak Abatement OIR (R.15-01-008).

8.3.2 Policy Considerations

This subprogram aligns and conforms with California's decarbonization goals through its direct relevance and applicability to several key policies, including:

Policy	Description
EO B-55-18	Carbon-neutral California economy by 2045
Clean Air Act	Air quality standards for NOx and PM
AB 32	Reduce CO2 emissions 40% below 1990 levels by 2030
SB 1383	Reduce methane emissions from decomposition of organic wastes
SB 1440	Authorizes a state procurement program for biomethane
LCFS	Reduce carbon intensity of fuels by 10% by 2020
AB 8	Development of 100 hydrogen refueling stations in California
EO B48-18	200 hydrogen refueling stations in California by 2025
Cal/OSHA Title 8 CCR	Injury and Illness Prevention Program
CPUC General Order 112F	Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems
DOT 49 CFR Part 192	Federal pipeline safety regulations

8.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: System Emissions**
  Projects in this research area seek to address post-combustion criteria air pollutants and GHG emissions. This research area supports the development of advanced technologies to detect, quantify, and provide real-time monitoring of emissions. Projects also include development of technologies or systems aimed at reduction or prevention of emissions. Projects are also needed to study diverse sources of energy and the effects on system emissions. This area supports the SoCalGas policy drivers for decarbonization, digitalization, and development of a diversified portfolio of energy sources. Resolution G-3601 directed that SoCalGas consider research on gas system decommissioning. Related projects will be added to this research area for 2023 (CY 2024).

- **Area 2: Environment**

This area includes projects related to the impact of diversified energy and to acquiring real-time information on the impact of ground subsidence and movement caused by drought and groundwater replenishment. Environmental projects focus on developing methods to prevent or mitigate contaminated water or hazardous waste run-off and preserve plants and endangered species during pipeline construction and repair within environmentally sensitive areas.

- **Area 3: Safety**
  The majority of safety incidents in the pipeline system are associated with third-party damage. Safety projects concerned with protecting the pipeline from intentional and unintentional damage include those developing 1) advanced sensors and monitoring systems to alert pipeline operators of third-party encroachment and construction activities near pipeline rights-of-way and 2) automatic shutoff systems for above- and belowground piping systems. Safety projects related to worker safety include those advancing training technologies and knowledge transfer.

8.3.4 Revised Funding Table

Revisions pursuant to Res. G-3601:

Gas Operations Program Environmental & Safety Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$432,844	-
Actual Incurred Cost Jan-Nov 2023	-	$337,129
Funds for Project Under Development for 2023	$296,113	$391,828
Reallocated Funds from Available Funding	-	$250,000
Total Sub-program Funding for 2023	$728,957	$978,957
Sub-program Percentage of Funding	20%	22%

8.4 Operations Technology

8.4.1 Subprogram Overview

This subprogram advances and develops advanced techniques for the construction, operation, maintenance, rehabilitation, and testing of gas pipelines and systems that facilitate continued safe and reliable service. It also supports technologies that improve employee training and explores how to prevent gas leaks that result from blending hydrogen into the pipeline.

8.4.2 Policy Considerations

Operations Technology projects support these key policies and regulations:

Policy	Description
DOT 49 CFR Part 192	Federal pipeline safety regulations
CPUC General Order 112F	Gas Transmission & Distribution rule
AB 32	GHG emission reduction targets

AB 1900	Biomethane quality standards
D.14-06-007	Approved SoCalGas' Pipeline Safety Enhancement Program

8.4.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Steel and Plastic Pipeline Construction, Operations, and Repair Technologies**
  Projects in this area would develop cost-effective polyethylene (PE) or steel pipe repair technologies that improve the efficiency of maintaining the integrity of the infrastructure. Projects in this area could also determine construction best practices for maintaining system integrity, such as how to eliminate strain on pipelines during installation. These projects improve the efficiency of maintaining the integrity of the infrastructure. Projects in the area also align with state goals to reduce GHG emissions by eliminating excessive methane emissions.
- **Area 2: Mapping and Locating Technologies**
  Projects in this area would improve pipeline locating and mapping technologies through, for example, further enhancement of acoustic, electromagnetic, and ground probing radar systems to produce complete accurate images of buried substructures. Other projects in this area could develop technologies for mapping underground pipelines and improving pipeline asset management. GIS mapping technologies are designed to improve the safety and integrity of underground natural gas pipelines by increasing the accuracy and availability of pipeline location information in areas where traditional methods and technology are inadequate. These technologies could help address excavation damage incidents caused by insufficient or inaccurate mapping methodologies. This research area supports the SoCalGas goal of digitalization, which includes the deployment of advanced technologies and analytics to improve planning, safety, resiliency, and the integration of real-time information to benefit participants across the energy value chain.
- **Area 3: Measurement, Equipment and Tools**
  Projects in this area would validate the capabilities of state-of-the-art measurement equipment and devices for both natural gas and other constituents, such as trace constituents in RNG. Through evaluation and testing of new methane hydrogen blend leak detection equipment, this research area supports the SoCalGas goals of decarbonization and diversity of energy. Resolution G-3601 directed that SoCalGas consider research on cybersecurity. Therefore, projects related to operations cybersecurity are being added to this research area.

8.4.4 Revised Funding Table

<u>Revisions pursuant to Res. G-3601:</u>

Gas Operations Program
Operations Technology Sub-program **2023 Funding Allocation**

	Initial Allocation	Revised pursuant to Res G-3601
Committed Funds for 2023	$299,844	-
Actual Incurred Cost Jan-Nov 2023	-	$264,851
Funds for Project Under Development for 2023	$246,874	$281,867
Reallocated Funds from Available Funding	-	$250,000
Total Sub-program Funding for 2023	$546,718	$796,718
Sub-program Percentage of Funding	15%	18%

8.5 System Design & Materials

8.5.1 Subprogram Overview

The objectives of this subprogram are to advance materials and materials science, materials tracking and traceability, and technical tools for designing pipeline systems and infrastructure for safety, reliability, efficiency, and maintainability throughout the life cycle of pipeline assets. Projects include research to advance engineering design standards and models, developing risk analytical tools to comply with pipeline integrity regulations, modeling operational efficiencies of gas storage and compressor station assets, and assessing the effects of incorporating gas from nontraditional sources (biogas) on overall natural gas quality and system integrity. Ultimately, lessons learned on these projects help SoCalGas better design, engineer, and develop its pipeline system.

<u>Revisions pursuant to Res. G-3601:</u>

Per Res. G-3601, research in the area of hydrogen-blending has been removed from this subprogram. See Appendix E for details on the applicable projects.

8.5.2 Policy Considerations

System Design & Materials projects support key policies and regulations:

Policy	Description
AB 32	Reduce CO2 emissions 40% below 1990 levels by 2030
CPUC General Order 112F	Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems
DOT 49 CFR Part 192	Federal pipeline safety regulations
AB 1900	Biomethane quality standards
Biomethane OIR Phase 3 (R.13-02-008)	Biomethane standards and requirements
ASME B31.8	Gas transmission and distribution piping systems

8.5.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Gas Composition and Quality**
  Natural gas quality affects the integrity and safety of the pipeline infrastructure and end-use combustion equipment. RNG from non-conventional sources contains trace constituents that can impact pipeline integrity and customer combustion equipment performance. RNG-related research projects in this area will seek to identify trace constituents and support establishment of upper limits for accepting RNG. In addition, projects in this area could develop cost-effective, miniature online volatile organic compound (VOC) and siloxane analyzers that have the detection levels and accuracies of laboratory equipment. This research area supports the SoCalGas goals of decarbonization and the development of a diversified portfolio of clean energy sources.
- **Area 2: System Design**
  Projects in this research area seek to improve the understanding of the implications of potential risk factors, such as stresses due to internal gas pressure, construction procedures, and environmental factors (corrosive and geohazards). Integrating this understanding with analytics of materials that mitigate these risks enables improvements in system design that can mitigate risks prior to installation. Development of metal loss criteria for anomalies in the pipeline enables the establishment of acceptable limits for pipelines operating at various pressures, which in turn enables the redesign of pipeline specifications and repair solutions to maintain system integrity. In addition, projects that focus on external loads—such as geohazards or construction hazards—create opportunities to better understand the stresses these hazards would potentially place on the pipeline, enabling these factors to be incorporated into the original design or retrofitted into legacy pipeline segments. Enhancing pipeline integrity addresses SoCalGas' decarbonization initiative by reducing the risk of pipeline damage that can cause methane emissions and determining impacts to the system infrastructure with the new diversified energy sources.
- **Area 3: Materials**
  Projects in this area will analyze state-of-the-art materials and coatings to identify those that can improve the longevity and therefore the reliability of newly installed pipeline segments over that of legacy installations. Area 3 projects could also help identify materials and coatings that are suitable for internal and external environments—knowledge that is key to maintaining a safe and reliable pipeline system. Understanding the advancements of both pipeline and weld materials will enable appropriate selections for the wide variety of environmental scenarios to which the pipeline will be exposed. With the acceptance RNG as key initiatives, work is being done to understand which materials would complement the anticipated change in the internal environment of the pipeline to maintain the integrity of the legacy system as well as incorporate that information into material selection for future designs of newly constructed segments. Research efforts for tracking and traceability projects improve the data collection of materials by developing an approach to streamline the traceability of steel assets and a marking standard for pipeline components.

8.5.4 Revised Funding Table

Revisions pursuant to Res. G-3601:

Gas Operations Program System Design & Materials Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$1,025,964	-
Actual Incurred Cost Jan-Nov 2023	-	$701,750
Funds for Project Under Development for 2023	$431,950	$756,163
Reallocated Funds from Available Funding	-	$250,000
Total Sub-program Funding for 2023	$1,457,913	$1,707,913
Sub-program Percentage of Funding	40%	39%

8.6 System Inspection & Monitoring

8.6.1 Subprogram Overview

The objectives for this subprogram include developing technologies and methods for inspection, monitoring, and testing of pipelines and pipeline components to assess the condition and performance of pipeline facilities. The goal is to improve system performance, reliability, safety, and operational efficiencies through data management to identify precursors to failures or incidents. Projects in this subprogram area leverage AI, machine learning, preventive and predictive maintenance technologies, including data analytic models and data lakes. Projects include innovative data sources such as Crowd Source and the Internet of Things (IoT). This subprogram also seeks to explore tools for managing the potential impacts of blending hydrogen into the gas pipeline.

8.6.2 Policy Considerations

System Inspection & Monitoring projects support key policies and regulations:

Policy	Description
AB 32	Reduce CO2 emissions 40% below 1990 levels by 2030
CPUC General Order 112F	Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems
DOT 49 CFR Part 192	Federal pipeline safety regulations
Clean Air Act	Air quality standards for Nox and PM

8.6.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Pipeline Systems Inspection Technologies**
  Projects in this area improve pipeline inspection technologies such as in-line and non-destructive examination (NDE). Projects continuing for 2023 include enhancing modules or sensors detection capabilities and extending the

inspection range for the Explorer robotic platform, and with developing non-destructive inspection technologies like using THz methods to interpret PE butt-fusion joint defects with 2D and 3D reconstruction imaging.

- **Area 2: Remote Pipeline Monitoring Systems**
  Projects in this area include the evaluation of remote inspection and monitoring systems. These non-intrusive technologies include satellite, aerial (manned and unmanned), and aboveground measurement of ground subsidence, methane emissions, distressed or dead vegetation, pipeline coating condition, and corrosion.
- **Area 3: Data Analytics**
  Digitalization of system information and advancing the use of data analytics are key strategies for improving system safety, reliability, and integrity in addition to being a pathway for achieving operational efficiency and emissions reductions. Leveraging machine learning, AI, image recognition, virtual and augmented reality technologies, neural networks, and advanced connectivity through social networks and IoT are examples of technologies that are being leveraged in a variety of research areas and proposals that are under development.
- **Area 4: Geohazard Threat Inspection and Monitoring**
  Projects in this area seek to monitor environmental threats, such as weather-related landslides and floods as well as seismic ground faults impacting pipeline integrity. This technology can provide continuous real-time measurement of strain imposed on the pipeline and alert pipeline operators to take mitigative measures to avoid pipeline failures. This research area supports the SoCalGas goal of digitalization.

8.6.4 Revised Funding Table

Revisions pursuant to Res. G-3601:

Gas Operations Program		
System Inspection & Monitoring Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$686,563	-
Actual Incurred Cost Jan-Nov 2023	-	$1,729,281
Funds for Project Under Development for 2023	$224,633	$0
Reallocated Funds from Available Funding	-	$0
Total Sub-program Funding for 2023	$911,196	$911,196
Sub-program Percentage of Funding	25%	21%

9 CLEAN TRANSPORTATION

The Clean Transportation Program area supports activities that minimize environmental impacts related to the transportation sector through the development of low-carbon fuels, zero-emissions drivetrains, fueling infrastructure, and on-board storage technologies. Other key objectives of this RD&D program area are to develop:

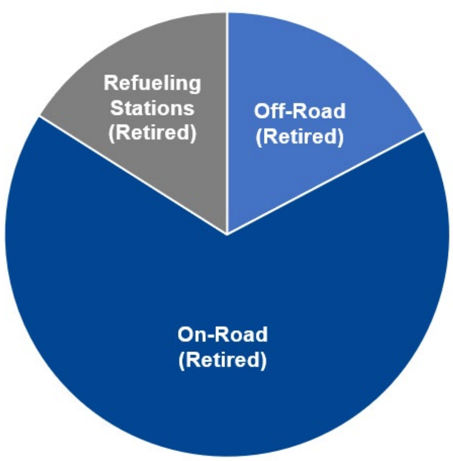
- Zero-emission transportation technologies
- Gaseous fueling infrastructure
- Advanced onboard storage technologies

The program invests in technology development projects in the following subprograms: 1) Off-Road, 2) On-Road, 3) Refueling Stations, and 4) Onboard Storage.

9.1 Proposed 2023 Clean Transportation Funding Allocation

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Off-Road, On-Road, Refueling Stations, and Onboard Storage subprograms in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for Off-Road, Onboard Storage, On-Road, and Refueling Stations includes actual and estimated incurred costs prior to the issuance of Res. G-3601.



Subprogram	Original Allocation	Revised Allocation
Off-Road (Retired)	30%	17%
Onboard Storage (Retired)	20%	0%
On-Road (Retired)	30%	67%
Refueling Stations (Retired)	20%	16%
Total	**$2,126,124**	**$1,134,579**

Figure 4: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Clean Transportation Program.

9.2 Off-Road (Retired)

9.2.1 Subprogram Overview

This subprogram targets emissions reductions from off-road vehicles such as rail, ocean-going vessels and commercial harbor craft, and construction and cargo handling equipment, where gaseous fuels can reduce emissions. Subprogram staff have also begun to explore aviation applications, including hydrogen fuel cell aircraft and drones.

The subprogram focuses on developing zero-emission off-road transportation solutions using renewable hydrogen and RNG.

Revisions pursuant Res. G-3601:

SoCalGas is retiring the Off-Road subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.1.6.

9.2.2 Policy Considerations

This subprogram aligns and conforms with several of California's decarbonization goals:

Policy	Description
EO N-79-20	100% zero-emission off-road vehicles and equipment by 2035 where feasible
CARB Clean Fleets Rule	Establishes a medium- and heavy-duty zero-emission fleet regulation with the goal of achieving a zero-emission truck and bus California fleet by 2045 where feasible
CARB At-Berth Regulations	Reduce diesel PM and Nox emissions from the auxiliary engines of ocean-going vessels while they are docked at California ports

9.2.3 2023 Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Zero-Emission Technology for Rail**
  For decades, diesel fuel has been the only realistic way to meet the demanding operating requirements in rail. As the demand for zero-emission transportation increases, alternative technologies continue to be the right solution for customers around the globe. Hydrogen fuel cells are recognized as one of the innovative solutions necessary for a carbon-neutral future, generating enough energy to power passenger and cargo trains. R&D in this area will help provide emission reductions that meet or exceed regulatory requirements. Fuel cell trains will play a key role in the transition to a zero-emission economy. Hydrogen-powered trains are poised to disrupt the rail industry as a cost-effective, high-performing, zero-emission alternative to diesel.
- **Area 2: Zero-Emission Technology for Marine**
  Off-road mobile sources account for over 40% of Nox emissions in the South Coast Basin. The marine industry is subject to new, stringent emissions standards. In addition, hoteling and shore-power for marine applications is a significant source of emissions in the basin. R&D in this area will help provide emission reductions that are surplus to regulatory requirements.
- **Area 3: Zero- and Near-Zero-Emission Technology for Construction Equipment**
  New diesel engines manufactured in the United States for construction vehicles such as wheel scrapers and wheel dozers are required to meet the EPA Tier 4 off-road standard of approximately 0.3 grams per brake horsepower-hour (g/bhp-hr) for Nox. In California, regulatory and competitive pressures are motivating fleet

owners to convert their older (Tier 3 or less) machines to Tier 4. Most older machines cannot be repowered (replace older engine with new one) to Tier 4 because the manufacturer does not have a Tier 4 retrofit package. Research in this area will help construction equipment and fleets meet Tier 4 standards in a cost-effective manner.

- **Area 4: Zero-Emission Technology for Aviation**
  Airlines have committed to carbon-neutral growth in international commercial aviation beginning in 2021. U.S. airlines have set a goal to achieve net-zero carbon emissions by 2050.[36] Although U.S. airlines have improved efficiency by 130% compared to 1978 levels, additional efficiency improvements in planes and engines are not likely to be enough. Meeting the 2050 goal will require fuels that have a lower carbon footprint. Hydrogen, with three times the energy density per mass of traditional jet fuel, is increasingly considered as one of the most promising zero-emission technologies for future aircraft.

9.2.4 Subprogram Benefits

Benefit	Explanation
Reliability	Fuel-cell electric vehicles (FCEVs) could reduce dependence on foreign oil because hydrogen can be derived from domestic sources, including renewable sources such as water, biogas, and agricultural waste. Zero-emission vehicles (ZEVs) require less maintenance than their gasoline and diesel counterparts.
Operational Efficiency	ZEVs require less maintenance and can refuel in the same amount of time as their diesel counterparts. FCEVs operate at higher fuel efficiency (60%) than internal combustion counterparts (20–30%).
Improved Affordability	ZEVs can benefit from incentives such as the LCFS.
Environmental: Reduced GHG Emissions	RNG and hydrogen fuel significantly reduce GHG emissions compared to diesel.
Environmental: Improved Air Quality	Vehicles emit a significant fraction of the air pollutants that contribute to smog and harmful particulates in California. Zero-emissions vehicles produce no tailpipe Nox or PM emissions.

9.2.5 Equity Considerations

ESJ communities are disproportionately affected by both mobile and stationary source (MSS) pollution. MSS reductions will highly benefit ESJ communities. This subprogram seeks rapid transition to zero-emission technology in and near ESJ communities, complementing AB 617 strategies and consistent with CARB's equity goals.[37]

9.2.6 Revised Funding Table

<u>Revisions pursuant to Res. G-3601:</u>

[36] See, *for example*, Airlines for America - https://www.airlines.org/airlines-fly-green/
[37] California Air Resources Board "2020 Mobile Source Strategy"

Clean Transportation Program		
Off-Road Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$273,949	-
Actual Incurred Cost Jan-Nov 2023		$21,036
Funds for Project Under Development for 2023	$363,888	$0
Estimated Incurred Cost Jan-Nov 2023[a]	-	$175,000
Total Sub-program Funding for 2023	$637,837	$196,036
Funds Available for Reallocation	-	$441,801
Sub-program Percentage of Funding	30%	17%

[a]Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

9.3 Onboard Storage (Retired)

9.3.1 Subprogram Overview

This subprogram targets the development, demonstration, and deployment of cost-effective technologies and systems that improve onboard storage for gaseous transportation fuels. Areas of focus include advanced materials, low-pressure systems, and conformable tanks for both compressed natural gas (CNG) and hydrogen. Onboard storage, which requires compressed storage and/or the use of advanced adsorption technologies, is a critical element needed for increased utilization of low-carbon, low-emission gaseous fuels.

<u>Revisions pursuant to Res. G-3601:</u>

SoCalGas is retiring the Onboard Storage subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.3.6.

9.3.2 Policy Considerations

Onboard Storage projects support multiple policies and regulations. Advancements In onboard hydrogen storage tanks for on-road and off-road applications can help reduce the size, weight, and cost of hydrogen vehicles. This can also increase range and efficiency to make hydrogen more favorable in different applications.

Policy	Description
EO B-48-18	5 million ZEVS by 2030; 200 hydrogen refueling stations by 2025
EO N-79-20	Eliminate new internal combustion engine vehicles by 2035; 100% light-duty vehicles and drayage trucks sold will be zero-emission by 2035; 100% MHD vehicles sold and operated are zero-emission by 2045

9.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Conformable and Low-Pressure Tanks**
  Projects in this area research improvements in the capacity, conformability, safety, and cost of on-board storage of gaseous fuels through development of conformable and low-pressure tanks. They will also research fueling protocols and applications to allow faster and fuller fills for RNG and renewable hydrogen.

9.3.4 Subprogram Benefits

Benefit	Explanation
Reliability	Low-pressure and advanced onboard storage tanks can provide greater cycle life and reduce required load on infrastructure.
Safety	Advanced materials can help store fuel at lower pressures and meet highest safety requirements of high-pressure storage vessels.
Operational Efficiency	Higher absorption and desorption materials can help reduce refueling times and fuller fills to maximize range and efficiency.
Improved Affordability	Low-pressure storage tanks require less compression and power needed to operate, and advanced onboard tanks help decrease costs.
Environmental: Reduced GHG Emissions	RNG and hydrogen fuel reduce GHGs given their lower carbon intensity relative to diesel.
Environmental: Improved Air Quality	Low-pressure storage tanks require less compression and power needed to operate.

9.3.5 Equity Considerations

"Investment in zero-emission transportation cannot be limited to electric cars, which are beyond the financial reach of many Californians. It must also be directed to clean transit, which will greatly benefit disadvantaged communities."[38]

[38] https://blog.ballard.com/public-transport-access

9.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Transportation Program		
Onboard Storage (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$29,855	-
Actual Incurred Cost Jan-Nov 2023	-	$0
Funds for Project Under Development for 2023	$395,370	$0
Estimated Incurred Cost Jan-Nov 2023 [a]	-	$0
Total Sub-program Funding for 2023	$425,225	$0
Funds Available for Reallocation	-	$425,225
Sub-program Percentage of Funding	20%	0%

[a] Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

9.4 On-Road (Retired)

9.4.1 Subprogram Overview

This subprogram targets emissions reductions from medium- and heavy-duty (MHD) on-road vehicles. The focus is on-road transportation technologies using renewable hydrogen and RNG.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the On-Road subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.4.6.

9.4.2 Policy Considerations

On-Road research projects support multiple policies and regulations:

Policy	Description
EO B-48-18	5 million ZEVs by 2030; 200 hydrogen refueling stations by 2025
EO N-79-20	Eliminate new internal combustion engine vehicles by 2035; 100% light-duty vehicles and drayage trucks sold will be zero-emission by 2035; 100% MHD vehicles sold and operated are zero-emission by 2045
CARB Clean Truck Rule	100% ZEV where feasible for drayage, public fleets, last-mile delivery by 2045
CARB Clean Fleet Rule	100% zero-emission trucks and buses where feasible by 2045

9.4.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Hydrogen Fuel Cell Development for MHD Trucks**
  Projects in this area perform research in advanced hydrogen fuel-cell electric vehicles (FCEVs) and zero-emission technologies for MHD freight and people transportation. Projects also demonstrate zero-emission vehicles (ZEVs) to encourage adoption of such technologies.
- **Area 2: Pathways for Zero-Emission Vehicles and Sustainable Transportation**
  Projects in this area perform studies on and assessments of advanced hydrogen FCEVs and zero-emission technologies for goods movement, transit, and transportation. Projects will also look at total cost of ownership, techno-economic analyses, planning, and roadmaps toward the adoption of ZEVs.
- **Area 3: Advanced Innovation and Connected Vehicles**
  Projects in this area perform research in state-of-the-art sustainable transportation technologies such as connected and autonomous vehicles (CAVs) to increase efficiencies in goods movement, public transportation, and ZEVs. Projects also demonstrate emissions reductions and efficiencies related to the adoption of CAVs.

9.4.4 Subprogram Benefits

Benefit	Explanation
Reliability	FCEVs could reduce U.S. dependence on foreign oil because hydrogen can be derived from domestic sources, including renewable sources such as water, biogas, and agricultural waste. ZEVs require less maintenance than their gasoline and diesel counterparts.
Operational Efficiency	ZEVs require less maintenance and can refuel in the same amount of time as their diesel counterparts. FCEVs operate at higher fuel efficiency (60%) than their internal combustion counterparts (20–30%).
Environmental: Reduced GHG Emissions	RNG and hydrogen fuel significantly reduce GHG emissions compared to diesel.
Environmental: Improved Air Quality	Vehicles emit a significant fraction of the air pollutants that contribute to smog and harmful particulates in California. Zero-emissions vehicles produce no Nox or PM emissions.

> "Reducing NOx emissions is vital to public health. As a precursor to smog, NOx can cause or worsen numerous respiratory and other health ailments and is also associated with premature death. All combustion engines produce NOx, and although technology has advanced markedly over the years, California must still do more to reduce NOx emissions from mobile sources, especially trucks."
>
> —California Air Resources Board

9.4.5 Equity Considerations

By seeking to develop zero-emissions MHD on-road vehicles, which frequently operate in ESJ communities, this subprogram will not only improve air quality, but also reduce GHG emissions—which will help reduce the impact of climate change. This program also supports development of zero-emission clean transit solutions, which typically benefit residents of ESJ communities more than other groups.

9.4.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Transportation Program On-Road Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$405,782	-
Actual Incurred Cost Jan-Nov 2023	-	$556,841
Funds for Project Under Development for 2023	$232,055	$0
Estimated Incurred Cost Jan-Nov 2023 [a]	-	$200,000
Total Sub-program Funding for 2023	$637,837	$756,841
Funds Available for Reallocation	-	$(119,004)[b]
Sub-program Percentage of Funding	30%	67%

[a] Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

[b] Funds available for reallocation are negative because some of the services rendered prior to the issuance of Res. G-3601, included in the "Estimated Incurred Costs Jan-Nov 2023" line, were performed towards milestones planned to be completed and paid in 2024 and beyond.

9.5 Refueling Stations (Retired)

9.5.1 Subprogram Overview

This subprogram targets the development, demonstration, and deployment of technologies and systems that support refueling for alternative fuels, including renewable hydrogen and RNG. The subprogram seeks to identify and manage concerns and issues arising from refueling of gaseous fuels—from storage to safety and standardization.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Refueling Stations subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.5.6.

9.5.2 Policy Considerations

Refueling Stations projects support multiple policies and regulations:

Policy	Description
AB 8	100 Hydrogen Refueling Stations in California
EO B-48-18	5 million ZEVs by 2030; 200 hydrogen refueling stations by 2025
Low Carbon Fuel Standard	Reduce carbon intensity in transportation fuels as compared to conventional petroleum fuels, such as gasoline and diesel

9.5.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Advanced Full Fill Technologies**
  Fast fill of compressed gas generates heat, which prevents full fill of the storage tank. Advanced full fill technologies help resolve this issue to provide full fills to CNG and hydrogen FCEVs. This helps alleviate range anxiety and promotes wider adoption of gaseous vehicles that significantly reduce emissions versus their liquid fuel counterparts.
- **Area 2: Hydrogen Refueling Station Optimization and Safety**
  Although hydrogen FCEVs have been researched and demonstrated, optimizing refueling infrastructure would enable broader adoption of these vehicles by transit and goods movement fleets. This research will look at improving hydrogen compressors, increasing the efficiency of overall refueling stations, and alternative technologies for refueling stations. Hydrogen and CNG as transportation fuel operate at high pressures: 10,000 pounds per square inch (psi) and 3,600 psi, respectively. Safety and standardization for station technologies are imperative for the successful adoption of both natural gas vehicles (NGVs) and FCEVs. Safety of refueling stations and components is a top priority for the station and vehicle operators of ZEVs.

9.5.4 Subprogram Benefits

Benefit	Explanation
Reliability	FCEVs could reduce U.S. dependence on foreign oil because hydrogen can be derived from domestic sources, including renewable sources such as water, biogas, and agricultural waste.

Safety	Technologies to reduce and mitigate potential risks in near-zero and zero-emission infrastructure to be as safe as gasoline stations.
Operational Efficiency	Optimizing refueling stations can decrease refueling times and supplement fueling for on-road vehicles and nearby buildings through distributed energy resources.
Improved Affordability	Optimizing refueling stations can decrease needed power for compressors and other equipment to reduce costs.
Environmental: Reduced GHG Emissions	RNG and renewable hydrogen fuel reduce GHGs given their lower carbon intensity relative to diesel.
Environmental: Improved Air Quality	Optimizing refueling stations can decrease emissions from additional devices that are essential to deliver the hydrogen to customers.

9.5.5 Equity Considerations

By seeking to develop technologies that enable deployment of hydrogen fueling infrastructure, this sub-program supports a broader deployment of FCEV's in all communities. However, since the effects of transportation pollution, including higher rates of asthma, are more pronounced in low-income communities,[39] supporting the deployment of zero emission transportation could help reduce air pollution and save up to 6,000 lives per year.[40]

9.5.6 Revised Funding Table

<u>Revisions pursuant to Res. G-3601:</u>

Clean Transportation Program		
Refueling Stations Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$29,855	-
Actual Incurred Cost Jan-Nov 2023	-	$118,263
Funds for Project Under Development for 2023	$395,370	$0
Estimated Incurred Cost Jan-Nov 2023 [a]	-	$63,439
Total Sub-program Funding for 2023	$425,225	$181,702
Funds Available for Reallocation	-	$243,523
Sub-program Percentage of Funding	20%	16%

[a] Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

39 https://www.uclahealth.org/news/asthma-disproportionately-affects-low-income-populations

40 https://www.nature.com/articles/news050620-12

10 CLEAN GENERATION

The Clean Generation program area targets the development and demonstration of high-efficiency products and technologies associated with the generation of power for the residential, commercial, and industrial market segments to reduce emissions, lower customer costs, integrate renewable fuels, and improve energy reliability and resiliency. Other key objectives of this Clean Generation program area are to:

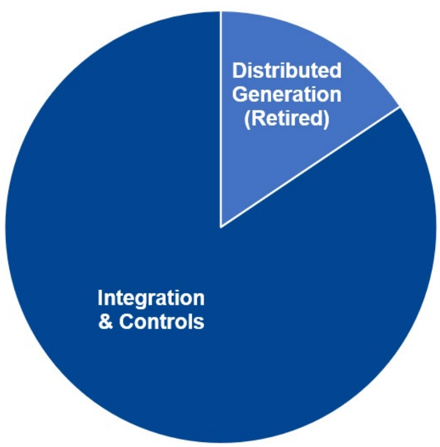
- Improve energy reliability and resiliency
- Reduce emissions of distributed generation (DG) technologies
- Reduce customer cost
- Improve DG integration and microgrid controls

The program invests in technology development projects in the following subprograms: 1) Distributed Generation and 2) Integration & Controls.

10.1 Proposed 2023 Clean Generation Funding Allocation

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Distributed Generation subprogram in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for Distributed Generation includes SoCalGas's existing contractual obligations for projects that are currently ongoing, as authorized by Res. G-3601.



Subprogram	Original Allocation	Revised Allocation
Distributed Generation (Retired)	50%	16%
Integration & Controls	50%	84%
Total	**$1,670,526**	**$2,061,741**

Figure 5: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Clean Generation Program.

10.2 Distributed Generation (Retired)

10.2.1 Subprogram Overview

This subprogram seeks to develop and enhance DG technologies. New DG technologies are needed to improve energy reliability and resilience and to incorporate increasing quantities of RNG and hydrogen.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Distributed Generation subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 10.2.6.

10.2.2 Policy Considerations

This subprogram develops reliable DG technologies with high efficiencies and increased RNG and hydrogen tolerance, resulting in reduced or eliminated emissions. Through these pathways, this subprogram supports several key policies.

Policy	Description
CPUC R.19-09-009	Microgrids and resiliency proceeding
AB3232	Building decarbonization
SB32	Reduce CO_2 emissions
Clean Air Act	Air quality standards for Nox and PM
SB 100	Zero-carbon electricity by 2045
EO B-55-18	Carbon-neutral California economy by 2045
SB 1298	DG regulation
SGIP	Self-Generation Incentive Program

10.2.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Commercialization of Small Scale (less than 50 kilowatt) Solid Oxide Fuel Cells (SOFCs)**
  Projects in this area seek to commercialize SOFCs for residential and small commercial customers. Small-scale SOFC units are widely available in Japan and Europe and recently are becoming increasingly available in South Korea. There are currently no commercially available small SOFCs in the United States. Lab testing, field demonstrations, system optimization, and safety certifications are required to introduce these products into the U.S. market.
- **Area 2: Hydrogen Integration with Existing Power Generation Technologies**
  Projects in this area seek to continue to test and identify pathways for increased levels of hydrogen blending for fuel cell, engine, and turbine-based DG technologies currently operating on natural gas. Identifying and increasing hydrogen thresholds of existing DG equipment is a critical component of meeting California's building decarbonization goals.
- **Area 3: Development of Low-emission CHP and Backup Generation**
  Projects in this area seek to develop and demonstrate low-emissions DG technologies that can help customers maintain energy resilience year-round, including during public safety power shutoff (PSPS) events and other grid disturbances, while limiting GHG and criteria pollutant emissions.

10.2.4 Subprogram Benefits

Benefit	Explanation
Reliability	Gas-fueled DG has the ability to provide highly reliable and resilient electricity to customers by enabling them to be partially or completely independent of the electric grid, when needed.
Operational Efficiency	Combined heat and power (CHP) systems have the ability to maximize customers' operational efficiency by productively using "waste heat," often offsetting other heating- and cooling-related energy consumption.
Improved Affordability	By improving the overall efficiency of DG technologies and microgrids, customer energy costs are reduced.
Environmental: Reduced GHG Emissions	Improving the efficiency (reduced fuel utilization) and increasing hydrogen tolerance of DG technologies result in lower GHG emissions.
Environmental: Improved Air Quality	Projects in this subprogram specifically focus on developing and demonstrating technologies that can meet or exceed CARB-DG certification standards, resulting in improved air quality.

10.2.5 Equity Considerations

Low-emission, DG technologies can provide energy resilience to vulnerable populations, such as medical baseline customers, during power outages—including those resulting from PSPS events. Deployment of diesel-replacing DG within industrial areas adjacent to low-income communities (LICs) improves air quality.

10.2.6 Revised Funding Table

<u>Revisions pursuant to Res. G-3601:</u>

Clean Generation Program		
Distributed Generation Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$137,763	-
Actual Incurred Cost Jan-Nov 2023	-	$196,334
Funds Needed to Complete In-Progress Projects	-	$125,000
Funds for Project Under Development for 2023	$697,500	$0
Total Sub-program Funding for 2023	$835,263	$321,334
Funds Available for Reallocation		$513,929
Sub-program Percentage of Funding	50%	16%

10.3 Integration & Controls

10.3.1 Subprogram Overview

This subprogram develops, enhances, and demonstrates technologies and control systems that integrate diverse DG resources and thermal loads. The focus is on enabling low-emissions, DG, and storage technologies to provide energy resilience and affordability to customers.

10.3.2 Policy Considerations

This subprogram aims to increase energy resilience and reduce customer emissions through the optimization of a "fully integrated energy system," leveraging and optimizing the utilization of low-emissions gas-fueled DG (such as fuel cells), on-site renewable generation, energy storage, and thermal systems. Integration & Controls projects support multiple policies and regulations:

Policy	Description
SB 1339	Microgrids for increased electricity reliability
CA Title 24	Buildings Energy Efficiency
CPUC R.19-09-009	Microgrids and Resiliency proceeding
AB3232	Building Decarbonization
SB 100	GHG emissions
Clean Air Act	Air quality standards for Nox and PM
EO B-55-18	Carbon neutral economy by 2045

10.3.3 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Integration and Optimization of Fuel Cells with Existing Customer Electric and Heating Systems**
  Projects in this area seek to develop and demonstrate hardware and software that enable the optimal integration of fuel cells with existing electric (including solar and battery storage) and heating systems at customer sites. Microgrids are typically highly customized, which results in high implementation costs. Identifying and demonstrating off-the-shelf components to simplify installations for customers will ideally reduce cost and other Integration complications. System complexity and lack of clear hardware requirements are significant barriers to adoption.
- **Area 2: Integration of Low-emissions Backup Generation with Existing Customer Electrical Systems to Provide Energy Resilience**
  Projects in this area seek to demonstrate how low-emissions backup generation can be seamlessly integrated with existing customer systems to provide increased resilience. This topic is targeted toward the integration of intermittent/backup generation with existing systems. With the increasing regularity of wildfires (and resulting PSPS events), customers and agencies are looking for alternatives to diesel backup generation and clarity on how low-emissions natural gas– or hydrogen-fueled generation technologies can address this need.

- **Area 3: Development of Technologies that Improve the Overall Efficiency of CHP Systems**
  Projects in this area seek to develop and demonstrate new technologies that optimize the utilization of "waste heat" from combined heat and power (CHP) systems. Improving the total efficiency of a CHP system by using a CHP system's heat can improve the emissions and economics of a fully integrated energy system.
- **Area 4: Development of Technologies that Improve Cybersecurity of Integrated Energy Systems**
  Projects in this area seek to research the needs and opportunities associated with improving cybersecurity in connected DG and microgrid technologies as well as to develop new technologies. With emerging fuel cells and microgrid technologies being connected to the cloud for remote monitoring and control purposes, there is a growing need to address potential cybersecurity concerns and threats.

10.3.4 Subprogram Benefits

Benefit	Explanation
Reliability	Ensuring that customer energy systems are integrated and optimized improves power reliability and resilience. Improving grid interaction of DG also improves reliability on both sides of the meter.
Safety	When power reliability and resilience are increased, customer safety is improved due to the ability to keep critical equipment, such as HVAC or medical devices, operating during grid outages.
Operational Efficiency	Optimizing the integration of gas-fueled DG with existing customer power systems and heating technologies ultimately improves the overall energy efficiency for a customer.
Improved Affordability	Developing "off-the-shelf" solutions for DG integration can reduce installation costs. In addition, the development of improved control systems can reduce customer energy costs.
Environmental: Reduced GHG Emissions	Optimizing the integration of low-emissions DG, such as fuel cells, with solar + storage and heat-driven appliances can greatly reduce CO_2 emissions by providing on-site electricity that is cleaner than grid-sourced electricity and potentially offset gas consumption when CHP is optimally utilized.
Environmental: Improved Air Quality	Integrating low-emissions DG, such as fuel cells, with solar + storage and heat-driven appliances can greatly reduce criteria pollutants (Nox) by providing on-site electricity that is cleaner than grid-sourced electricity and potentially offset gas consumption when CHP is optimally utilized.

10.3.5 Equity Considerations

By simplifying and standardizing DG integration, installation costs will decrease, making resilience and energy efficiency more affordable. In addition, by simplifying the integration of clean generation technologies, the need for dirtier forms of backup generation decreases, resulting in improved air quality in DACs.

10.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Generation Program Integration & Controls Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$756,858	-
Actual Incurred Cost Jan-Nov 2023		$433,022
Funds for Project Under Development for 2023	$78,405	$402,241
Funds Reallocated from Available Funding		$905,144
Total Sub-program Funding for 2023	$835,263	$ 1,740,407
Sub-program Percentage of Funding	50%	84%

Additional funding reallocated to the Integration & Controls subprogram supports several ratepayer benefits. Advancing the commercialization of technologies that enable microgrid deployment will provide ratepayers with increased energy reliability. Research to reduce the cost of integrating distributed generation technology within existing customer energy systems have the potential to provide ratepayers with a more affordable energy supply. Streamlining the integration of low- or zero-emissions distributed generation technology will create environmental benefits for ratepayers by reducing GHG emissions and criteria pollutant emissions.

Additional funding reallocated to the Integration & Controls subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given time-constraints of this program year.

11 CUSTOMER END-USE APPLICATIONS

The Customer End-Use Applications Program area focuses on developing, demonstrating, and commercializing technologies that cost-effectively improve the efficiency and reduce the environmental impacts of gas equipment used in residential, commercial, and industrial settings. Other key objectives of this program area are to:

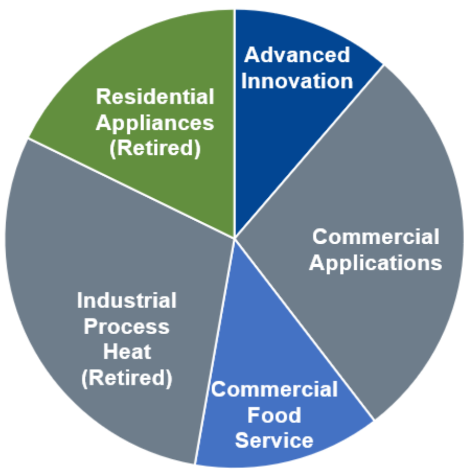
- Support the development and deployment of technologies that meet air emissions and energy efficiency goals
- Increase safety and performance while reducing cost

The program invests in technology development projects in the following subprogram areas: 1) Commercial Food Service, 2) Residential Appliances, 3) Commercial Applications, 4) Industrial Process Heat, and 5) Advanced Innovation.

11.1 Proposed 2023 Customer End-Use Applications Funding Allocation

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Industrial Process Heat and the Residential Appliances subprograms in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for Industrial Process Heat includes SoCalGas's existing contractual obligations for projects that are currently ongoing, as authorized by Res. G-3601. The revised 2023 funding allocation proposed for Residential Appliances includes SoCalGas' existing contractual obligations prior to the issuance of Res. G-3601.



Subprogram	Original Allocation	Revised Allocation
Advanced Innovations	6%	11%
Commercial Applications	15%	28%
Commercial Food Service	7%	10%
Industrial Process Heat (Retired)	40%	29%
Residential Applications (Retired)	32%	21%
Total	**$2,126,124**	**$2,013,401**

Figure 6: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Customer End-Use Applications Program.

11.2 Advanced Innovation

11.2.1 Subprogram Overview

This sub-program seeks to develop new, nontraditional technologies to improve energy efficiency and decrease emissions.

11.2.2 Policy Considerations

Advanced Innovation projects support key policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency

Policy	Description
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements
LEED	Building sustainability and stewardship

11.2.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Smart Appliances**
  Projects in this research area will investigate the use of smart technology to optimize energy efficiency and reduce gas consumption. For example, projects may explore advanced construction technologies and building materials that can improve building energy efficiency or assess new innovations—such as machine learning, blockchain, 3D multi-sensor transmitters, robotics, augmented reality, or improved cybersecurity—for applicability to emissions reduction, increased efficiency, and improved safety.
- **Area 2: Advanced Materials for Building Energy Efficiency**
  Projects in this research area will investigate the use of advanced construction technologies and building materials. This includes prefabricated material, vacuum insulation panels, or phase-change glass.

11.2.4 Subprogram Benefits

Benefit	Explanation
Safety	These innovations increase customer safety by monitoring for equipment failures (for example, leaks, performance degradations, emissions increases). Reduced fuel consumption, smart air monitoring, and advanced ventilation also improve local air quality.
Operational Efficiency	These innovations aim to provide operational efficiencies by directly targeting building performance and optimizing energy systems to yield the highest total efficiency.
Improved Affordability	Identifying new technologies that provide energy efficiency results in lower customer energy costs.
Environmental: Reduced GHG Emissions	By reducing energy usage, these innovations provide environmental benefit by reducing associated GHG emissions.

Environmental: Improved Air Quality	By reducing energy usage, these innovations provide environmental benefit by reducing associated NOx and PM emissions.

11.2.5 Equity Considerations

Smart technologies and advanced building techniques and materials have the ability to provide energy efficiency at lower costs than complete retrofits. This can result in meaningful energy savings without burdensome upfront capital costs for lower income households.

11.2.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program Advanced Innovation Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$7,365	-
Actual Incurred Cost Jan-Nov 2023	-	$67,031
Funds for Project Under Development for 2023	$120,203	$60,537
Funds Reallocated from Available Funding		$100,059
Total Sub-program Funding for 2023	$127,568	$227,627
Sub-program Percentage of Funding	6%	11%

Additional funding reallocated to the Advanced Innovation subprogram supports several ratepayer benefits. Advancing the commercialization of technologies that enable advanced construction technology and advanced building materials will provide ratepayers with increased operational efficiency. Increased efficiency will reduce fuel consumption, providing customers with the benefits of reduced emissions and improved affordability. Moreover, the additional funding reallocated to the Advanced Innovation subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

11.3 Commercial Applications

11.3.1 Subprogram Overview

This subprogram develops and enhances technologies and advancements related to gas consumption and end uses in the commercial sector. Relevant applications include commercial HVAC, hot water service, and commercial laundry.

11.3.2 Policy Considerations

Commercial Applications projects support key policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: High-Efficiency Commercial Equipment for Building Decarbonization**
  Projects in this area seek to develop a variety of high-efficiency equipment, including commercial water heating, space conditioning, and heating, cooling, and refrigeration process equipment, with the goals of increasing energy efficiency and reducing NOx emissions.
- **Area 2: Hydrogen Blends in Commercial Equipment**
  Projects in this area seek to investigate how hydrogen blends impact the performance of commercial equipment, with particular focus on NOx emissions and energy efficiency. Projects will identify feasible modifications to equipment to accommodate higher blends.

11.3.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance for commercial equipment also provides improved operational efficiency for customers by reducing fuel cost associated with space conditions, water heating, and other commercial operations.
Improved Affordability	Increased energy efficiency improves cost savings. This reduces overhead expenditures for businesses and delivers an attractive ROI to adopt high-efficiency technologies.
Environmental: Reduced GHG Emissions	Developing advanced end-use equipment that is compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from commercial buildings.
Environmental: Improved Air Quality	Increasing energy efficiency and burner performance for commercial equipment provides an environmental benefit by reducing NOx and PM emissions.

11.3.5 Equity Considerations

Buildings are part of the community. Where office buildings are located determines who will have access to the jobs they house, how much energy they use, and how much waste they produce. Therefore, the goal of this subprogram is to provide highly efficient and socially responsible technology to the built environment that improves the quality of life for all people.

11.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program		
Commercial Applications Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$47,186	-
Actual Incurred Cost Jan-Nov 2023	-	$23,085
Funds for Project Under Development for 2023	$271,733	$295,834
Funds Reallocated from Available Funding	-	$250,146
Total Sub-program Funding for 2023	$318,919	$569,065
Sub-program Percentage of Funding	15%	28%

Additional funding reallocated to the Commercial Applications subprogram supports several ratepayer benefits. Advancing the development of technologies that enable increased operational efficiency will reduce fuel consumption, providing customers with the benefits of reduced emissions and improved affordability. Moreover, this additional funding reallocated to the Commercial Applications subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

11.4 Commercial Food Service

11.4.1 Subprogram Overview

This subprogram develops and enhances technologies and advancements related to commercial food service (CFS). CFS includes restaurants, catering services, and institutional kitchens that primarily rely on fuel supplied by SoCalGas for cooking and water heating. In response to the COVID-19 pandemic, this subprogram may also explore new solutions, such as adaptation to increased outdoor dining.

11.4.2 Policy Considerations

This subprogram aligns and conforms with California's decarbonization goals through its direct relevance and applicability to several key policies, including:

Policy	Description

2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.4.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Hydrogen and RNG Blends in Commercial Food Service Equipment** Projects in this area seek to develop highly efficient commercial food service equipment that is compatible with hydrogen and RNG blends.
- **Area 2: Low-Cost, Low-Emission Commercial Food Service Equipment** Projects in this area seek to develop safe, efficient, and effective technologies such as next-generation burners, gas heat pump water heaters, and kitchen ventilation systems. This area also supports projects that promote adoption of new high-efficiency equipment through technology development, demonstrations, webinars, conference presentations, and journal publications.

11.4.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance also provides improved operational efficiency for customers by reducing cooking time, increasing food output, and reducing fuel cost.
Improved Affordability	Increasing energy efficiency and burner performance results in energy cost savings and reduced total cost of ownership.
Environmental: Reduced GHG Emissions	Projects in this subprogram seek to increase energy efficiency and burner performance, which provides GHG benefit by reducing emissions from CFS equipment.
Environmental: Improved Air Quality	The CFS sector is a highly energy-intensive sector. Improved burner performance and energy efficiency significantly reduces GHG and NOx emissions.

11.4.5 Equity Considerations

Half of all American adults have worked in the restaurant industry. This subprogram seeks to reduce emissions, improve air quality, and increase profitability for an important sector that employs more minority workers than any other industry.[41]

11.4.6 Revised Funding Table

<u>Revisions pursuant to Res. G-3601:</u>

Customer End-use Applications Program Commercial Food Service Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$102,531	-
Actual Incurred Cost Jan-Nov 2023	-	$0
Funds for Project Under Development for 2023	$46,298	$148,829
Funds Reallocated from Available Funding		$54,880
Total Sub-program Funding for 2023	$148,829	$203,709
Sub-program Percentage of Funding	7%	10%

Additional funding reallocated to the Commercial Food Service subprogram supports several ratepayer benefits. Advancing the development of technologies that enable increased operational efficiency in cooking and water heating applications will reduce fuel consumption, providing customers with the benefits of reduced emissions and improved affordability. Moreover, this additional funding reallocated to the Commercial Food Service subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

11.5 Industrial Process Heat (Retired)

11.5.1 Subprogram Overview

This subprogram develops advanced heating technologies and systems for use in the industrial sector. In particular, the industrial process heat end-use sector represents some of the largest users of gaseous fuels and the most difficult applications to decarbonize. Examples include food processing, manufacturing, cement production, chemical processing, textile drying, and agriculture.

<u>Revisions pursuant to Res. G-3601:</u>

[41] https://restaurant.org/about/our-industry/commitment-to-diversity-equity-and-inclusion

SoCalGas is retiring the Industrial Process Heat subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 11.5.6.

11.5.2 Policy Considerations

Industrial Process Heat projects support key policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
SB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.5.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Heavy Industrial Process Equipment**
  This research area seeks projects that increase energy efficiency of industrial process heat applications and reduce NOx emissions. This can include high-performance burners, waste heat recovery devices, carbon capture and utilization, smart systems, and sensors.
- **Area 2: Hydrogen Blends in Industrial Equipment**
  Industrial processes, with high energy loads and high temperature requirements, are extremely difficult to electrify. Projects in this area will investigate how hydrogen blends impact the performance of industrial equipment, with particular focus on NOx emissions.

11.5.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance for industrial equipment improves operational efficiency for industrial customers by reducing fuel costs associated with high-temperature processes and improving throughput.
Improved Affordability	Developing solutions that can be implemented as modifications or retrofits to existing equipment allow for cost-effective and energy-efficient decarbonization of industrial end uses.

Environmental: Reduced GHG Emissions	Developing advanced industrial equipment that is compliant with RNG and hydrogen reduces GHG emissions from industrial processes, which are difficult and costly to electrify.
Environmental: Improved Air Quality	Increasing energy efficiency and burner performance for industrial equipment provides an environmental benefit by reducing NOx and PM emissions.

11.5.5 Equity Considerations

Industrial facilities typically neighbor LICs and DACs. This subprogram aims to improve energy efficiency and replace conventional fuels with RNG and hydrogen, which can significantly reduce emissions and improve air quality in these regions.

11.5.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program Industrial Process Heat Sub-program (Retired) 2023 Funding Allocation		
	Original Allocation	**Updated per Res G-3601**
Committed Funds for 2023	$313,091	-
Actual Incurred Cost Jan-Nov 2023	-	$236,623
Funds Needed to Complete In-Progress Projects	-	$356,605
Funds for Project Under Development for 2023	$537,359	$0
Total Sub-program Funding for 2023	$850,450	$593,228
Funds Available for Reallocation		$257,222
Sub-program Percentage of Funding	40%	29%

11.6 Residential Appliances (Retired)

11.6.1 Subprogram Overview

This subprogram develops, demonstrates, and enhances technologies and advancements related to gas-consuming appliances in residences. Subprogram staff also seek to adapt proven technologies to the California market. Relevant appliances include furnaces, hot water heaters, stoves, ovens, and dryers.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Residential Appliances subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 11.6.6.

11.6.2 Policy Considerations

Residential Appliances projects support multiple policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Building Decarbonization
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.6.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Hydrogen and RNG Blends in the Home**
  Projects in this area seek to develop highly efficient residential appliances that are compatible with hydrogen and RNG blends.

11.6.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance for residential appliances also provides improved operational efficiency for customers by reducing fuel cost associated with space conditions, water heating, and cooking.
Improved Affordability	Increased energy efficiency improves cost savings and ensures that energy is affordable and equitable.
Environmental: Reduced GHG Emissions	Developing advanced appliances that are compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from residential buildings.
Environmental: Improved Air Quality	Increasing energy efficiency and burner performance for residential appliances provides an environmental benefit by reducing NOx and PM emissions.

11.6.5 Equity Considerations

The introduction of hydrogen may have higher upfront costs than conventional fuels. Therefore, high-energy-efficiency appliances in the residential space will have greater importance in ensuring that clean energy is affordable and equitable.

11.6.6 Revised Funding Table

<u>Revisions pursuant to Res. G-3601:</u>

Customer End-use Applications Program Residential Appliances Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$616,599	-
Actual Incurred Cost Jan-Nov 2023		$177,022
Funds for Project Under Development for 2023	$63,760	$0
Estimated Incurred Cost Jan-Nov 2023 [a]		$242,750
Total Sub-program Funding for 2023	$680,359	$419,772
Funds Available for Reallocation		$260,587
Sub-program Percentage of Funding	32%	21%

[a]Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

12 Appendix A: Stakeholder Input

In early 2022, SoCalGas RD&D conducted outreach to 11 organizations and spoke to 15 different individuals. Key takeaways from this year's outreach include:

1. Leverage existing infrastructure to decarbonize.
2. Hydrogen is a key technology for decarbonization.
3. Study the impact of transporting low-carbon fuels—RNG and hydrogen—and carbon dioxide in existing and new pipelines, as well as ways to retrofit existing pipelines.
4. Explore blending of hydrogen and natural gas in a natural gas power plant.
5. There is a need for more distributed hydrogen production at refueling stations.
6. Explore different ways to transport hydrogen, including liquid and ammonia.
7. Support development of dispensers, hoses, and other equipment for 10 kg/min hydrogen refueling for heavy-duty trucks.
8. Explore hydrogen production that does not consume water.
9. There is a need for more workforce development and training for students, technicians, first responders, and engineers in hydrogen and other new technologies.
10. Continue to support gas heat pump technology, particularly at greater than 100% efficiency.
11. Get ahead of regulation and police yourself using a variety of technologies and leak detection methods to reduce fugitive methane emissions.
12. Develop commercial-scale CCUS projects—including direct air capture—to prove that they can work.
13. Focus on developing data collection standards, artificial intelligence, and real-time sensors.
14. Develop protocols for low-carbon heavy-duty refueling processes.
15. Educate policy makers about safety, reliability of natural gas, hydrogen, and RNG, as well as realistic timelines for the energy transition.
16. Explore non-destructive evaluation technologies for pipelines, as well as ways to better predict and prevent corrosion.
17. Fuel cell technology needs a lot of investment.
18. Explore how to track green molecules in the pipeline and give credits.
19. Demonstrate use of gaseous fuels for heavy-duty transportation.
20. Study how to integrate gas and electric systems for resilience.
21. Support research into thermochemical conversion of woody biomass.
22. Pursue technologies with potential to reduce energy costs for ESJ communities.
23. Increase diversity through student programs.

13 Appendix B: Public Workshop Questions & Comments

B1	Submitter: Vishnu Vijayakumar, **UC Davis** (vvijayakumar@ucdavis.edu) **Q:** Are there any plans for SoCalGas to get into building hydrogen refueling stations? **A:** This question falls outside the scope of RD&D. SoCalGas' plans to develop hydrogen refueling stations are being addressed through the general rate case (GRC) process. Please refer to SoCalGas's GRC Test Year 2024 Application 22-05-015 for more information.
B2	Submitter: Paul Sandsted, **NGV America** (psandsted@ngvamerica.org) **Q:** As far as clean transportation, where RD&D is concerned, are there specific vehicle applications that your team focuses on? **A:** SoCalGas RD&D has historically focused primarily on heavy-duty on-road vehicle applications, particularly around developing and demonstrating ultra-low-NOx or near-zero-emissions compressed natural gas (CNG) heavy-duty truck engines. The focus has recently shifted toward fuel cell electric vehicles—particularly in the heavy-duty space. SoCalGas RD&D has also started exploring off-road applications, including rail, marine, and aviation. After decades of emissions reductions in the on-road sector, emissions from these off-road sectors now exceed those from on-road. Emissions reductions for off-road applications are critical to achieving decarbonization and air quality targets.
B3	Submitter: Debolina Dasgupta**, Argonne National Laboratory** (ddasgupta@anl.gov) **Q:** Can microgrid resilience be provided by CHP systems in addition to diesel? **A:** Yes, combined heat and power (CHP) systems can provide resilience like diesel backup. However, CHP systems typically operate full-time, also providing "waste heat" for heating or cooling processes—instead of only powering on for backup power. If a CHP system is sized to provide the majority of a site's power, then a customer will benefit from full/near-full energy resilience. There are also natural gas and hydrogen power generation technologies that perform similarly to diesel backup systems, only providing power when needed.
B4	Submitter: Carrie Berard, **NYSEG** (caberard@nyseg.com) **Q:** Great job Karen [McInnis]. **A:** Thank you.
B5	Submitter: Marianne Mansour, **SoCalGas** (Mmansour@socalgas.com) **Q:** Has there been research in storage of CO_2 and [the] possibility of using our underground storage facilities?

	A: SoCalGas Gas Operations RD&D does not currently have any active projects related to the underground storage of CO_2. However, projects are being developed related to carbon sequestration and storage by various research consortia. (see question B54).
B6	Submitter: Rizaldo Aldas, **California Energy Commission** (rizaldo.aldas@energy.ca.gov) **Q:** I may have missed this. Are you currently limiting your distributed generation (DG) focus on scales of below 50 kW, and, if so, what were the main drivers for that? **A:** The SoCalGas RD&D Distributed Gas subprogram is not limited in focus to sub-50kW technologies. RD&D is also interested in developing and advancing new technologies across various sizes, for a wide range of customer applications. However, RD&D included sub-50kW fuel cells as a research area due to an identified technology gap for smaller systems in the United States, and specifically California. There are several models of residential and small commercial-sized fuel cells available in Japan and Europe, with over 400,000 systems installed in Japan. RD&D staff believe that these technologies can provide several environmental and resiliency benefits in California.
B7	Submitter: Submitter: Rizaldo Aldas, **California Energy Commission** (rizaldo.aldas@energy.ca.gov) **Q:** It sounds like you've identified a gap in the product space for that size of fuel cell. So that is a focus for developing small-scale fuel cell products? Does that sound accurate? **A:** Yes, that's correct**.**
B8	Submitter: Kevin Uy, **California Energy Commission** (kevin.uy@energy.ca.gov) **Q:** Is there a projected level of RD&D funding for 2022-2023? **A:** Yes. Projected 2022 RD&D funding is discussed in the 2022 Research Plan, which was approved by the California Public Utilities Commission (CPUC) in Resolution G-3586. Projected 2023 funding is listed in Section 6.1 of this document.
B9	Submitter: Claire Becker-Castle, **SoCalGas** (cbecker-castle@socalgas.com) **Q:** The last two minutes of video were not seen on screen. **A:** We apologize for the inconvenience.
B10	Submitter: Cynthia Carter, **SoCalGas** (ccarter5@socalgas.com) **Q:** Only a comment. This is a great workshop! I'm excited for our future.

	A: Thank you.
B11	Submitter: Ludwig Lipp, **T2M Global** (llipp@t2mglobal.com) **Q:** Power for ships at the Los Angeles and Long Beach ports is a major source of pollution. SoCalGas should consider supporting fuels for clean power production for marine applications, including hydrogen. **A:** Thanks for the feedback. This is something that RD&D is interested in and will consider looking at for future projects. In fact, RD&D is currently pursuing a grant funding opportunity to provide fuel cell shore power at the ports.
B12	Submitter: Michael Slusarz, **American Gas Association** (mslusarz@aga.org) **Q:** Thank you, RD&D Team, for the great presentations. Looking forward to continuing the discussions! **A:** Thank you for participating in this public workshop.
B13	Submitter: Siari Sosa, **SoCalGas** (ssosa@socalgas.com) **Q:** Thanks all! Great presentation, very informative! **A:** Thank you for participating in this public workshop.
B14	Submitter: Bianca Tippett, **Sowing Seeds for Life** (receptionist@sowingseedsforlife.org) **Q:** This was not covered yet. How can charities better partner with the gas company to best provide services to those living food-insecure? **A:** RD&D is part of SoCalGas, a larger company that provides charitable giving programs, grant opportunities, scholarship funding, diversity and inclusion efforts, and supplier diversity. SoCalGas RD&D is happy to connect you with the correct group within SoCalGas to help facilitate those relationships. Please contact us by email at RDDInfo@socalgas.com.
B15	Submitter: Kaycee Chang, **California Energy Commission** (kaycee.chang@energy.ca.gov) **Q:** What target metrics would you be looking for around hydrogen-blended power generation? **A:** RD&D is considering several potential metrics at this time. One key metric is impact on performance, such as reduced efficiency or an increase in NOx emissions. Another key metric is impact to system durability and longevity. For example, does the hydrogen affect any components that would require shorter service intervals? Are catalysts affected? If there are any other metrics you believe that RD&D should focus on, please let us know.
B16	Submitter: Adele DiBiasio, **National Grid** (adele.dibiasio@nationalgrid.com)

	Q: Will your slide deck be available? **A:** A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B17	Submitter: Ishita Dave, **SoCalGas** (Ishah1@scgcontractor.com) **Q:** Thanks all, presenters and Matthew, for providing all this technical info through great presentations. **A:** Thank you for participating in this public workshop.
B18	Submitter: SanSan Lee, **SoCalGas** (sslee@socalgas.com) **Q:** First time attending the workshop. Excellent materials. Will take a day off to attend the workshop next year so the focus can be on the workshop only. Thank you. **A:** Thank you for participating in this public workshop.
B19	Submitter: David Blekhman**, Cal State LA** (blekhman@calstatela.edu) **Q:** Great vision. It would be great to implement small-scale fuel cells at Cal State LA for training, research, and demo projects through senior designs. Excellent job. We appreciate all the work that went into this event. Hopefully, more to come. We look forward to future collaborations. **A:** Thank you for the suggestion. We will consider this for future projects.
B20	Submitter: Zhiming Gao, **ORNL** (gaoz@ornl.gov) **Q:** How can we contact SoCalGas RD&D for a collaboration? **A:** Please contact us by email at RDDInfo@socalgas.com. Please provide a brief description of the collaboration opportunity so that SoCalGas RD&D can make sure it gets directed to the right group.
B21	Submitter: Zhiming Gao, **ORNL** (gaoz@ornl.gov) **Q:** How about NOx control in gas combustion? **A:** SoCalGas RD&D considers six distinct ratepayer benefits—such as emissions reductions, cost-savings, and operational efficiency—that help guide the direction of its research. The Gas Operations program has funded and continues to fund projects that examine NOx reduction methods through air-fuel ratio controllers, catalysts, and various other mechanisms. The Customer End-Use Applications subprogram has focused on advanced combustion burners that specifically address NOx emissions as well as the implementation

	of catalysts after treatment across residential, commercial, and industrial market segments. Lastly, SoCalGas RD&D has ramped up its research into hydrogen blending to address burner performance and combustion emissions of carbon monoxide and NOx.
B22	Submitter: Bob Coleman, **SoCalGas** (rwcoleman@socalgas.com) **Q:** I understand that the goal is to get hydrogen down to $1/kg and it is currently at $2/kg, though I could have this wrong. What are the improvements that need to take place to get from where we are to the goal? **A:** SoCalGas RD&D would like to clarify that while costs for hydrogen may be as low as $2/kg, those prices are typically for hydrogen produced from fossil gas sources and with no greenhouse gas emissions mitigation. Renewable hydrogen production costs are typically in the range of $5-$10/kg depending on the feedstock and pathway. That said, the DOE has identified several key areas in which costs must be reduced in order to achieve a renewable hydrogen cost of $1/kg. These primarily involve capital expense and operating expense reductions. SoCalGas RD&D supports projects and technology developments that aim to address multiple technological pathways to produce renewable hydrogen, including supporting projects to de-risk and advance cutting-edge technology as well as projects that help to further develop existing technologies to improve efficiency or reduce manufacturing costs. For electrolysis, the primary driver to reduce operating expenditures (OpEx) is reducing renewable electricity costs. On the capital expenditure (CapEx) side, RD&D supports projects to decrease electrolyzer module cost by identifying earth-abundant materials that can replace the expensive and scarce platinum group metal materials typically used in electrolysis. For other technological pathways, RD&D has supported projects in many research areas that aim to reduce OpEx by increasing reactor efficiencies. For example, RD&D has supported the development of advanced, modular, and scalable steam methane reforming (SMR) reactors that can convert renewable natural gas (RNG) to renewable hydrogen. RD&D has also supported the development of methane pyrolysis technologies that produce valuable carbon byproducts that help offset the cost of hydrogen produced through this method.
B23	Submitter: Peter Chen, **California Energy Commission** (peter.chen@energy.ca.gov) **Q:** Is there flexibility with reallocating funding across subprograms? **A:** Yes, two key goals of the public workshop are to share the proposed allocations across subprograms for 2023 and to obtain stakeholder feedback.
B24	Submitter: Peter Chen, **California Energy Commission** (peter.chen@energy.ca.gov)

	Q: What applications/sectors are interested in low-pressure hydrogen storage? Are there issues with scalability considering the established 350/700 bar standards for refueling on-road hydrogen fuel cell vehicles? **A:** Low-pressure hydrogen storage could reduce the weight of the storage tank on the vehicles in many different transportation applications. Low-pressure storage could also to reduce the energy requirements and reliability issues that come with high-pressure hydrogen storage. Low-pressure hydrogen storage may require new fueling standards and potentially require modification of the current fueling infrastructure, which is designed to operate at high pressure.
B25	Submitter: Emily Chow, **Public Utilities Commission** (emily.chow@cpuc.ca.gov) **Q:** Regarding the Food Service subprogram, will restaurant operators receive any grants or stipends that will help them purchase high-efficiency equipment in combination with the educational opportunities mentioned? **A:** The SoCalGas Energy Resource Center (ERC) offers seminars, demonstrations, and consulting services to help local businesses find cost-effective, energy-efficient solutions. The webpage is located at: https://www.socalgas.com/for-your-business/education-and-training/energy-resource-center. This past year, the ERC offered customers a complete virtual experience to help them select and acquire rebates for high-efficiency equipment during the pandemic. On the rebate side, SoCalGas was able to offer a 50% deemed rebate until 12/31/2021. The ERC has also been working on offering grants for restaurant workers through the California Restaurant Foundation.
B26	Submitter: Emily Chow, **Public Utilities Commission** (emily.chow@cpuc.ca.gov) **Q:** What a fantastic workshop! Is there anywhere we can sign up to receive notifications for future SoCalGas workshops like this one? **A:** All attendees of the public workshop you are automatically added to the SoCalGas RD&D email list to receive notification of future workshops and webinars. Anyone interested in signing up for notification should contact us by email at RDDInfor@socalgas.com.
B27	Submitter: Michael Allawos, **Allawos & Company** (michael.allawos@allawosandcompany.com) **Q:** Was it correct that there is over $8 billion available for the production of hydrogen for local hubs? Can you please show the slide that illustrates this? **A:** This was slide 58 in the presentation. The bipartisan infrastructure law (BIL) has allocated $8 billion in DOE funding to support at least four regional hydrogen hubs. See[https://www.energy.gov/articles/doe-establishes-bipartisan-infrastructure-laws-95-billion-clean-hydrogen-initiatives for more information.

B28	Submitter: Michael Allawos, **Allawos & Company** (michael.allawos@allawosandcompany.com) **Q:** Would SoCalGas be interested in a partnership with San Bernardino International Airport to go after the $8 billion for a proposed hydrogen production facility to provide hydrogen for aircraft? **A:** The hydrogen hubs funding opportunity is primarily being handled outside of RD&D. SoCalGas RD&D will pass along the information to the team that is looking at proposed hydrogen hub activities.
B29	Submitter: Sean Anayah, **California Energy Commission** (sean.anayah@energy.ca.gov) **Q:** Public Utilities Code (PUC) 740.1(d) states that projects should not unnecessarily duplicate research undertaken by other organizations. How does SoCalGas ensure non-duplicity? Thanks. **A:** One of the one of the key ways SoCalGas RD&D strives to eliminate non-duplicity is by working through research consortia that will be described in more detail later in the public workshop. Research consortia tend to be organizations composed of multiple research entities and utilities across the United States and even North America. If, for example, a utility on the East Coast is conducting similar research, SoCalGas RD&D would be aware of it through working with them through its consortia efforts. In working with these research consortia, SoCalGas RD&D has the opportunity to leverage funding by pooling and coordinating funding from multiple resources. Other ways SoCalGas RD&D strives for non-duplicity are through review by subject matter experts on staff, workshops, connecting with the research community, attending conferences, and generally developing its network of researchers from across the United States and around the world. These efforts help SoCalGas RD&D stay up to date on the current state of the art and conduct research that advances technology without duplicating work that's already been done.
B30	Submitter: Sean Anayah, **California Energy Commission** (sean.anayah@energy.ca.gov) **Q:** Has the utilities' obligation to serve (CPUC 451) been considered as electrification replaces gas services? **A:** This question falls outside the scope of RD&D.
B31	Submitter: Sean Anayah, **California Energy Commission** (sean.anayah@energy.ca.gov) **Q:** How does SoCalGas propose to alleviate the burden to commercial food services, industry, and residents with future required installations of high-efficiency technologies?

	A: Generally speaking, SoCalGas could help alleviate the burden by improving or increasing the incentives to help reduce customer costs. SoCalGas can also help in this space by providing education on the type of technology available to the customer base. One of the major problems associated with the turnover to high-efficiency equipment is that not a lot of restaurant operators are aware that the technology exists. Thus, education and outreach will be a great resource to help address this concern. Two examples of such programs outside of SoCalGas RD&D are the customer programs that develop incentives for high-efficiency equipment and the Energy Resource Center, which includes a demonstration kitchen where customers can test out new, high-efficiency equipment and learn more about it.
B32	Submitter: Charles Sponberg, **SoCalGas** (csponberg@socalgas.com) **Q:** Are there any micro projects that would digest home food and yard clippings into methane that could then make power? **A:** SoCalGas RD&D has engaged with Cal State University, Los Angeles on its senior design projects over the past few years. One of the senior design projects involved operation of a Home Biogas Unit, a small anaerobic digester designed to fit into a residential backyard. The methane produced could then be used to operate a small cooking device. More information about this project is available on page 36 of the SoCalGas RD&D 2019 Annual Report.
B33	Submitter: Charles Sponberg, **SoCalGas** (csponberg@socalgas.com) **Q:** What is the longevity and reliability outlook for the fuel cells in use and for lower-cost future fuel cells? **A:** The fuel cells that SoCalGas RD&D is looking into have a claimed longevity of five to ten years, depending on the fuel cell technology and manufacturer. In most cases, the systems have much longer lifespans, only requiring the fuel cell stack (catalyst) to be replaced at the five-to-ten-year mark. Assessing degradation in power output is one of the goals for RD&D lab and field evaluations of new technologies. In addition, some of the systems require minimal maintenance, such as filter replacements. As for the reduction in fuel cell cost, this is something RD&D hopes to achieve through its projects—both directly through foundational research into new fuel cell technologies and indirectly through demonstrating the benefits, providing a pathway to scaled production.
B34	Submitter: Charles Sponberg, **SoCalGas** (csponberg@socalgas.com) **Q:** I may have missed it, but will this presentation be available for viewing again?

	A: A recording of the full workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B35	Submitter: David Xu, **PG&E** (dxx2@pge.com) **Q:** How does your company conduct deployment of the completed R&D projects? **A:** If the technology reaches commercialization, one pathway is to use the technology internally for potential deployment in SoCalGas operations. For other technologies and products, SoCalGas RD&D seeks to identify a good commercialization pathway for those technologies. Such pathways may include a commercialization partner to help a startup company or a technology provider to bring that technology to market. SoCalGas RD&D then works to advance that technology into the commercial space so that it can provide benefit to SoCalGas customers.
B36	Submitter: David Xu, **PG&E** (dxx2@pge.com) **Q:** How is your upper management's support of the R&D [projects]? [Have there been] budget increases or decreases in recent years? **A:** The SoCalGas RD&D program and the annual budget are authorized by the CPUC via the General Rate Case process. Budget allocations outlined in the Research Plan are submitted to the CPUC via a Tier 3 Advice Letter and approved annually by Resolution.
B37	Submitter: David Xu, **PG&E** (dxx2@pge.com) **Q:** Can the current infrastructure handle the hydrogen? If so, what [is] the supporting evidence? If not, what is the viable plan and the associated cost estimation? **A:** Research is being conducted to perform due diligence on all portions of the existing gas infrastructure to determine the effect of various blends of hydrogen. The status of existing projects can be found in the 2021 RD&D Annual Report, Appendix *2021 Summary of Ongoing and Completed Projects*. Since research is ongoing, publications are pending.
B38	Submitter: Arezoo Khodayari, **California State University, Los Angeles** (akhoday@calstatela.edu) **Q:** Thank you for the great update. What is the plan to sustain the collaboration and partnerships that you have established with your current university partners? **A:** Part of the workshop outreach effort is to engage with current SoCalGas RD&D research partners as well as new research stakeholders to help identify new technologies and research areas. RD&D looks forward to continuing to

	have those discussions with its current and potential research partners to refine the research program and the plan for 2023.
B39	Submitter: Arezoo Khodayari, **California State University, Los Angeles** (akhoday@calstatela.edu) **Q:** Will there be an update later today about the status of the hydrogen blending with natural gas and its prospects? **A:** Today's presentation won't cover any specific projects in great detail, as there is a lot to cover in the 2023 Research Plan, but please feel free to e-mail rddinfo@socalgas.com with a specific question.
B40	Submitter: Arezoo Khodayari, **California State University, Los Angeles** (akhoday@calstatela.edu) **Q:** How can we see the list of participants here on the dashboard? Also, how can we change the name that appears on the screen? **A:** Our workshop platform does not have the functionality to show all attendees during the broadcast. For a list of organizations represented at the workshop, please refer to section 3.2 of this document.
B41	Submitter: Norman Pedersen, **Southern California Generation Coalition** (npedersen@hanmor.com) **Q:** Where will you post the workshop feedback questions and other handouts on the SoCalGas website? See the Public Workshop Notice. **A:** A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd. The workshop feedback questions are included in this document in Appendix B and C.
B42	Submitter: Norman Pedersen, **Southern California Generation Coalition** (npedersen@hanmor.com) **Q:** Where will you post the slide deck on the website? **A:** A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B43	Submitter: Norman Pedersen, **Southern California Generation Coalition** (npedersen@hanmor.com) **Q:** In your feedback question #2 about power generation, are you talking about fueling the power generation with blended fuel or fueling with 100% hydrogen? If the latter, how would you separate the hydrogen from the blended gas flow?

	A: For question #2, we are specifically talking about hydrogen blended fuel. However, we are also interested in achieving 100% hydrogen utilization in some cases. The ultimate goal would be for the customer to receive hydrogen (blended or pure), and for their equipment to be compatible the fuel composition received. **Q:** In the case of 100% hydrogen, how would the hydrogen be separated from the blended gas flow? Is the question: "In the future if there was a supply of 100% hydrogen, could we enable the power generation to be fueled along that supply?" **A:** Ideally, when hydrogen is delivered to the customer, whether 100% hydrogen or blended with natural gas, the customer's equipment would function normally without the need to separate the hydrogen. If the hydrogen needed to be separated from the natural gas for a specific use case, there are technologies that can facilitate this, such as the HyET hydrogen separation technology highlighted on Page 23 of the 2021 RD&D Annual Report.
B44	Submitter: Julieta Lafond, **Sempra** (JLafond@semprautilities.com) **Q:** Will you be describing more on what type of projects are part of the allocations, e.g., Low Carbon Resources, Customer End-Use Applications? **A:** Yes. The workshop presentation includes deep dives into each of the five programs within RD&D. The presentations describe what each program focuses on and what research areas have been identified for 2023. A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B45	Submitter: Julieta Lafond, **Sempra** (JLafond@semprautilities.com) **Q:** Will there be collaborations with disposal companies to enable users and communities to donate their organic waste? **A:** Thank you for the suggestion. This type of strategy will likely be required to enable RNG at scale. In some municipalities, organic waste is already going to an anaerobic digester to make renewable natural gas, which then fuels the waste hauler's fleet. For example, CR&R Environmental is injecting renewable natural gas produced at CR&R's anaerobic digestion facility in Perris, California, into the SoCalGas pipeline. For more information, visit the SoCalGas website: https://www.socalgas.com/sustainability/renewable-gas/rng-success-stories/crr-environmental.
B46	Submitter: Lorna Holt, **SoCalGas** (lmholt@socalgas.com) **Q:** You showed a list of benefits. Is there a particular benchmark used for the overall benefits? **A:** Thank you for the question. SoCalGas RD&D has a rigorous project selection process. The projects are first vetted and the benefits to SoCalGas ratepayers

	identified. Then, RD&D staff conduct an internal review for funding approval before the project moves forward.
B47	Submitter: Lorna Holt, **SoCalGas** (lmholt@socalgas.com) **Q:** Do you know when other workshops will be held? Are they quarterly? **A:** SoCalGas RD&D holds a public workshop once a year to help prepare the following year's research plan. In addition, SoCalGas RD&D holds quarterly research webinars where RD&D staff and project research partners share details of projects that are active or have been recently completed. Recordings of past webinars and information about upcoming webinars can be found on the RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B48	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** How and to what extent does SoCalGas coordinate its research projects with the Gas Research Institute? **A:** The Gas Research Institute (GRI) merged with Institute of Gas Technology (IGT) to become the GTI Energy in 2000. SoCalGas RD&D has maintained a close and long-standing relationship with GTI Energy and its predecessors. SoCalGas RD&D also coordinates a number of research projects through consortia. GTI Energy is an important part of the ecosystem for generating new projects, coordinating new research teams, and applying to funding solicitations. GTI Energy administers both the Operations Technology Development and Utilization Technology Development consortia.
B49	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Does the research program include analyses of alternatives to underground storage fields such as Aliso Canyon? Has SoCalGas studied means of making these underground storage fields less prone to explosions or methane releases? **A:** Currently, SoCalGas RD&D is not funding research in alternatives to underground storage fields. The SB1371 Leakage Abatement RD&D Program has funded research to detect, quantify, and minimize methane emissions at SoCalGas facilities including underground storage fields. For more information, see https://www.socalgas.com/regulatory/R1501008.
B50	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Has SoCalGas conducted research on preventing large-scale transmission lines from failures in the desert area? **A:** Yes. SoCalGas has conducted research supporting pipeline integrity, including improving inspection technologies such as inline inspection (ILI) tools to detect corrosion and mechanical damage through the research consortia Pipeline Research Council International and NYSEARCH. The status of existing

	projects can be found in the 2021 RD&D Annual Report, Appendix *2021 Summary of Ongoing and Completed Projects*.
B51	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Doesn't renewable natural gas create GHG emissions when it is burned by the end user? What are the net GHG emissions when RNG is used by regular end users? **A:** Burning natural gas, whether renewable natural gas (RNG) or fossil-sourced natural gas, produces GHG emissions at the point source. However, from a perspective of net GHG emissions and net carbon intensity, RNG results in reduced GHG emissions and lower carbon intensity compared to fossil-sourced natural gas. In many cases, RNG can demonstrate net-zero or net-negative carbon intensities. Please see the California Air Resources Board's (CARB) most recent GREET modeling outputs demonstrating negative carbon intensities of RNG, particularly when used as a transportation fuel, at https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation. For context, the feedstock that is used as an input to produce RNG is primarily diverted from waste streams—including dairy manure, forestry residues, organic food waste, and other biomass—that would otherwise emit large quantities of methane. Methane has a much higher carbon intensity than CO_2. By diverting those feedstocks to produce fuels such as RNG, those methane emissions are reduced or eliminated. Additionally, the RNG that is produced can displace demand for fossil-sourced natural gas, resulting in further emissions reductions and increased environmental benefits.
B52	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** How much RNG is potentially available to supply California natural gas users? Could as much as 50% of supply come from RNG sources? **A:** A recent CARB inventory report on GHG emissions has demonstrated that as much as 7% of California's GHG emissions comes from agricultural and forestry activities. Much of these can be diverted to produce RNG. The California legislature has passed several bills regarding expanding RNG development or procurement. For example, SB 1383 involved reduction of biogenic methane emissions and resulted in the development of large-scale anaerobic digestion as a means to divert waste streams to produce RNG. As a result of SB 1440, California will explore managing its woody biomass resources and waste forestry and agricultural residues through gasification or pyrolysis to produce biomethane, deliver RNG, and reduce short-lived climate pollutant emissions.

	SoCalGas is seeking to increase the proportion of RNG in the natural gas it delivers to its customers. Currently, SoCalGas' goal is for RNG to make up 20% of all natural gas it delivers by 2030.
B53	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Does the production of RNG produce toxic chemicals or other waste products that must be disposed of safely? **A:** There are multiple pathways—including biomethanation, anaerobic digestion, and gasification—that can produce RNG. In addition, multiple feedstocks can be used as inputs in these pathways. However, RNG is most often produced from biogas sources, such as the anaerobic digestion of animal and food waste, landfills, and wastewater treatment facilities. These biogas sources produce roughly a 60:40 mixture of methane and carbon dioxide, respectively, that is separated using gas separation technologies such as membranes, amine scrub, and pressure swing adsorption. Other ways to produce RNG are the conversion of carbon dioxide using hydrogen in biomethanation or thermochemical process that produce nearly pure methane. In general, production of RNG does not, by necessity, result in toxic chemicals that need to be managed, stored, or disposed of. During certain processes using specific feedstocks, some toxic compounds can be produced temporarily and often in small quantities, usually at parts-per-million (ppm) levels; these are usually destroyed, converted, or neutralized in later steps of processing. Regarding biogas sources, hydrogen sulfide is produced naturally along with carbon dioxide and methane during the decomposition of our waste streams and ranges from 50 to 5,000 ppm by volume but can reach up to 20,000 in some cases. Hydrogen sulfide is easily removed from renewable and fossil natural gas using well established technologies that are common in the oil and gas industry. In addition to hydrogen sulfide, siloxanes can be produced from landfills and may be present in landfill gas. Tars can be formed during the first stage of gasification if it is conducted at low temperatures. SoCalGas does not allow any toxic content, from RNG or otherwise, into its gas grid.
B54	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Right, and has there been research in storage of CO_2, and possibly using SoCalGas underground storage facilities? **A:** SoCalGas RD&D has not supported any efforts to store CO2 at any SoCalGas' underground storage sites, however, SoCalGas RD&D have participated in a CO2 injection and storage study in the central valley with Clean Energy Systems (CES) that was completed and presented in SoCalGas' RD&D 2019 Annual

	Report. RD&D staff are open to evaluating potential research projects in this area involving geologic or other long-term sequestration. SoCalGas RD&D has supported several projects looking at utilizing CO2 to produce fuels or durable products, such as building materials or plastics.
B55	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** The San Bruno explosion happened in part because of a power failure at a PG&E compressor station. When the power came back on, there was a surge of pressure that may have triggered the explosion. Is SoCalGas conducting research on how to prevent this type of incident in its transmission system? **A:** The San Bruno incident occurred in 2010. Much has transpired since then to address the issues involved. SoCalGas has pressure control systems in place to trip and prevent system over-pressurization. Basic Process Control Systems and Safety Systems are designed to have redundant sources of power supply.
B56	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Why has the repair on Line 400 taken so long and what can be done to speed up the restoration process? **A:** This question falls outside the scope of the SoCalGas RD&D Program.
B57	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Has SoCalGas explored the use of treated effluent water as a source of water for hydrogen electrolysis? **A:** Our understanding is that treated effluent water can always be further treated to reach purity levels required for existing electrolyzer technology. SoCalGas RD&D has not yet been involved in any projects that have explored directly electrolyzing low-purity water, such as brackish or effluent water.
B58	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Does SoCalGas anticipate delivering hydrogen to fueling stations via pipeline or via trucks? **A:** RD&D is investigating several avenues for supplying fueling stations with hydrogen, including separating hydrogen from a blend of gases delivered by pipeline[42] and modular electrolyzers for distributed hydrogen production.[43]
B59	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Are there any active research programs regarding using hydrogen in maritime settings?

[42] Renewal: SoCalGas RD&D 2021 Annual Report, p.23
[43] Renewal: SoCalGas RD&D 2021 Annual Report, p. 78

	A: There are currently two such active projects. To learn more, see the SoCalGas RD&D 2021 Annual Report on pages 167 and 168. The relevant project titles are “CALSTART Hydrogen Zero Emission Tugboat Design” and “GGZEM Harbor Craft Demonstration.” Both projects received H2RAM funding from the CEC.
B60	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Is EPRI doing comparable research on fuel cell backup power applications? Is SoCalGas coordinating with their efforts? **A:** We are not aware of any active EPRI fuel cell projects at this time. However, they have conducted such projects in the past and are interested in the technology. We regularly coordinate and participate in projects directly with EPRI. We also participate in the Low Carbon Resources Initiative, which EPRI co-manages.
B61	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Fuel cells have been available for many years, but they seem to be like nuclear fusion projects, too many years in the future to be practical. Have fuel cell costs declined in recent years and is lowering their costs a focus of your research? **A:** There has been a steady decrease in fuel cell prices over the past decade in Japan, where the ENE-FARM program has deployed over 400,000 fuel cells to residential customers. This is a result of technology advancements and market scale. This type of price reduction is something that RD&D is interested in achieving in California. RD&D is interested in directly reducing costs through fundamental research as well as demonstrating the benefits of fuel cells in the field so they can achieve widespread adoption.
B62	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Do fuel cells require the use of expensive imported rare earth elements or other hard-to-obtain materials? **A:** This is dependent on the fuel cell technology, as well as the manufacturer. Each system is a little different; some technologies do not require precious metals. Developing technologies that reduce the use of these materials is of interest to SoCalGas RD&D.
B63	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Is the CAISO supportive of the increased use of fuel cells on the grid? Are fuel cells forecast to be an important source of generation over the next 20 years? **A:** The RD&D team can’t speak to this, but SoCalGas does have policy teams dedicated to working with CAISO and other regulators to address this question.
B64	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com)

	Q: For industrial and commercial applications, will customers have to replace existing end-use devices—boilers, fryers, etc.—to use hydrogen as a fuel source instead of natural gas? **A:** The Customer End-Use Applications subprogram is actively working with researchers and original equipment manufacturers to develop solutions that enable the SoCalGas customer base to retrofit its existing end-use devices to use blends of hydrogen. It remains to be seen how this will play out in the long term, when pure hydrogen might be the main fuel source, but it is a topic that SoCalGas RD&D is exploring.
B65	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** What type of safety issues does the use of hydrogen present to end users and the existing pipeline systems? It is my understanding that pure hydrogen can degrade existing pipelines and I would anticipate end-use equipment as well. **A:** There are potential safety concerns regarding burner flashback that SoCalGas RD&D is currently exploring, but preliminary research suggests that at low blends of hydrogen (0-30%), flashback is typically not a concern and there are no major safety hurdles at the lower blends. As far as the higher blends are concerned, flashback could be a part of SoCalGas RD&D research. RD&D staff are currently exploring design improvements to reduce any possible safety issues. Gas Operations RD&D is currently funding research to identify any potential safety considerations or gaps that need to be addressed with the addition of hydrogen blends to the natural gas infrastructure. The status of existing projects can be found in the SoCalGas RD&D 2021 Annual Report, Appendix 2021 *Summary of Ongoing and Completed Projects*.
B66	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Is SoCalGas looking into using fuel cells as a source of battery-type storage for use when renewable generation declines in the late afternoon/evening? **A:** This is one of the use cases that SoCalGas RD&D is interested in researching and demonstrating around fuel cells. Hydrogen could be generated from renewable energy during the day via electrolysis, stored, and then used to fuel a fuel cell to produce power. This could be done at the microgrid level behind the meter or at grid scale. In addition to reducing emissions in the evening, hydrogen storage and fuel cells help improve energy resilience.

14 Appendix C: Post-Workshop Stakeholder Input

C1	Submitter: Ron Chong, **Road Runner** (ron.chong@roadrunner.com) **Q:** Thanks for the opportunity to participate in the Public Workshop last Wednesday. It was interesting to see the wide variety of projects past and present. Maybe you could share some of these projects to business and residential users, especially those which will be beneficial by lowing their carbon footprint and utility bills. A handout could be inserted into the utility bills, maybe quarterly and/or promoted online. A few comments on hydrogen blending. Hydrogen's energy content is lower than methane on a volume basis and this will lower the heating value supplied to consumers. What does that do to the amount of gas that is combusted? How much more gas has to be consumed for cooking and heating? Does it raise the price for the consumer? **A:** You are correct when you say hydrogen contains less energy, by volume, than natural gas. Since hydrogen is less dense than natural gas, however, a gas blend flows faster than pure natural gas. Thus, for many residential appliances, a greater volume is delivered and combusted to produce the same amount of heat. Notably, this isn't true for all applications. At low hydrogen blend ratios, the lower energy content is approximately canceled out by the higher flow rate, and the overall amount of heat delivered is similar. At higher blend ratios, though, the gas eventually reaches a maximum flow rate and the amount of heat delivered also reaches a maximum value. At some ratio, this maximum heat value becomes increasingly less by volume than that of pure natural gas. The higher flow rate does not necessarily cause the bill to increase, however, because SoCalGas charges by energy content, not by volume. Some combustion effects, like flame size, may affect heat efficiency and thus energy usage.
C2	Submitter: Ron Chong, **Road Runner** (ron.chong@roadrunner.com) **Q:** Hydrogen is known to cause embrittlement in some metal at certain pressures and temperatures. In the refinery, hydrogen attacks stainless steel and causes it to crack. Will it affect the burner material on our cooktops similarly? **A:** Cooktops operate at relatively low pressures, so embrittlement is not expected to be as problematic as it can be in high-pressure cylinders and pipes. Due to the proximity of the hydrogen flame, though, the cooktop burner may grow too hot, which could affect durability. The SoCalGas RD&D team is actively planning to look into this.
C3	Submitter: Ron Chong, **Road Runner** (ron.chong@roadrunner.com) **Q:** SoCalGas injects mercaptan (sulfur) to odorize methane gas for safety. Will the addition of hydrogen in natural gas result in a reaction of the hydrogen with the sulfur to form hydrogen sulfide (H2S)? If there is any moisture present in the natural gas, it may form an acid solution and cause

	corrosion because the pipes to deliver natural gas to homes are galvanized steel pipes. What are the safety issues in using high hydrogen content in the natural gas delivered to residences? **A:** The SoCalGas RD&D team does not expect sulfur compounds to react with hydrogen at room temperature in the distribution system, but it could be different in power plants. Sulfur compounds could form sulfur dioxide (SO_2) upon combustion and would then be converted to sulfite (SO_3) on a Selective Catalyst Reduction (SCR) catalyst. The RD&D team is actively evaluating the effect of hydrogen blends on SCR catalyst performance in the presence of SO_2. Downstream of the SCR unit at lower temperatures, SO_3 would react with water vapor to form sulfuric acid which would likely cause corrosion issues.
C4	Submitter: Rick Brown, **Aspen** (rick.brown.138@gmail.com) **Q:** Can you send a link to the location of the webinar PowerPoint presentation? **A:** A recording of the workshop is available on our website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd. Look for the section labeled "Public Workshop Notice" and follow the link marked "View Recording."
C5	Submitter: Vicki Shattuck, **Spire Energy** (vicki.shattuck@spireenergy.com) **Q:** I was able to attend the webinar yesterday and had thought I downloaded the deck but am unable to find it now. Can you give me access to the presentation from yesterday? **A:** A recording of the workshop is available on our website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd. Look for the section labeled "Public Workshop Notice" and follow the link marked "View Recording."
C6	Submitter: Bianca Tippett, **Sowing Seeds for Life** (receptionist@sowingseedsforlife.org) **Q:** It was nice to listen in on the webinar. I will tell you right now I had no idea that SoCalGas Company has so many projects each year to help save energy. Your beginning spokesman Mathew Gregori was very well spoken and knew what he was talking about. I did have a couple questions. First, in what ways can we, at home, try to save on energy? Are there certain windows we should have or particular types of appliances? Second, what type of scholarship funding do you provide? **A:** Please visit our "Ways to Save" webpage:

	https://www.socalgas.com/save-money-and-energy/energy-saving-tips-tools/ways-to-save. You can complete your Energy Profile and get a household energy analysis and customized energy-efficiency recommendations. You can also build a personalized Savings Plan to help you keep track of your energy-efficiency progress and ultimately help lower your bills. Please, also, visit the Scholarship Program webpage: https://learnmore.scholarsapply.org/socalgas/ SoCalGas has established a scholarship program to assist current high school seniors in select Southern California counties who plan to continue their education in college pursuing a STEM, finance, or accounting field of study. The program is administered by Scholarship America®, the nation's largest designer and manager of scholarship, tuition assistance, and other education support programs for corporations, foundations, associations, and individuals.
C7	Submitter: Bianca Diaz-Hladek, **Mar Vista Family Center** (bdiaz@marvistafc.org) **Q:** It's really great that SoCalGas is working to provide a better environment using natural gas. I especially appreciate the effort in reaching out to all communities through partnerships with universities and non-profits that SoCalGas can support with ensuring that underrepresented communities are included. I would like to learn more about how we can support these efforts through providing education to families in our community. Are there or will there be workshops that our staff can attend to implement this in our programming? I believe that getting people in our community to make environmental issues a priority is a great challenge for different reasons, one being the fear of higher prices. What is the best way for non-profits, that work directly with the community, to support these efforts in partnership with SoCalGas? Thank you so much for the opportunity to participate in the webinar and become informed of the RD&D Program. **A:** All attendees of the public workshop are automatically added to the RD&D email list to receive notification of future workshops and webinars. Anyone interested in signing up for notification should contact us by email at RDDInfor@socalgas.com.
C8	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** I recently read an article in the Los Angeles Times about the effects that heavy truck traffic coming to and from the Ports of Long Beach and Los Angeles are having on a low-income area of Wilmington. I believe that hydrogen-fueled trucks and locomotives could substantially (if not largely) eliminate much of the particulate and nitrous oxide pollution associated

	with heavy freight hauling operations near the port. Because many of the vehicles and locomotives involved are part of larger corporate fleets, it makes sense to focus on converting these vehicles to hydrogen and/or batteries as a first step towards decarbonizing transportation. I urge SoCalGas to pursue research initiatives in this area. **A:** The emissions from heavy-duty trucks traveling to and from the ports are a significant contributor to local air pollution. As you noted, this pollution often affects many disadvantaged communities located near the ports and along inter- and intra-state trucking corridors. SoCalGas RD&D currently has several active projects focused on heavy-duty trucking. Examples can be seen on pages 172-178 of the 2021 RD&D Annual Report. In addition, RD&D plans to allocate 30% of the 2023 Clean Transportation budget to On-Road projects, which focus on developing and demonstrating zero-emission vehicles to help address this critical issue, while simultaneously meeting the technical needs of fleet operators.
C9	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** The increased use of renewable generation in California and adjacent states has created a mismatch between peak power generation periods and times of peak demand, which typically arise after renewable generation declines. I urge SoCalGas to develop an RD&D project that would use excess renewable generation (in California) to power electrolysis of water to produce hydrogen that could be used in adjacent fuel cells to serve as a backup power source similar to battery storage. Rather than sending excess generation out of state, this excess generation could be used to create "green" hydrogen that could in turn power fuel cells as surrogate batteries. I recognize that SoCalGas's research program and budgets have already been set for 2022/2023, but I urge you to explore this option in your future research endeavors. **A:** We agree that the current dynamic with renewable energy production and customer energy use provides a good opportunity for hydrogen and fuel cells. This is an area RD&D is exploring developing more projects around. SoCalGas RD&D currently has two active projects with UC Irvine that seek to address this issue: “UCI Hydrogen Enabled Microgrids for Critical Infrastructure Research” and “UCI Hydrogen Energy Storage and Integration with Dispatchable Power Generator System Design.” The latter of these is co-funded by the DOE. RD&D is also in the process of finalizing the contract on another related DOE-co-funded project with the National Renewable Energy Laboratory and GKN Hydrogen.
C10	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** I'm curious about the relative efficiencies of natural gas heat pumps versus electric heat pumps. Has SoCalGas (or someone else) examined the overall carbon footprints of these two technologies? **A:** For residential applications, GTI Energy published a study last year that compared a gas heat pump (GHP)-based combi system (furnace/water heater replacement) to alternatives, including electric heat pump options, using experimentally calibrated building energy models. The primary

	takeaway was that for the climate zones modeled, the GHP option provides the least-cost and lowest-GHG-emission approach for the current grid mix. This publication can be found at: https://docs.lib.purdue.edu/ihpbc/354/.
C11	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** It is my understanding that carbon capture and storage is an expensive technology and that the prospect of future leaks of the stored gas is a continuing concern. Has SoCalGas explored the possible commercial use of stored carbon dioxide? **A:** SoCalGas RD&D has worked with commercialization partners to help develop technology that can utilize CO_2 by conversion to durable goods like building materials and plastics or to fuels. RD&D has also supported projects to upgrade biogas by conversion of CO_2, through biomethanation, to RNG.
C12	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** Has SoCalGas or GTI, or any other group looked into whether there are inexpensive or low-tech means of modifying existing gas transmission and distribution pipelines to carry hydrogen? **A:** Currently, the focus of research has been on identifying the impact of introducing natural gas hydrogen blends into the existing infrastructure and determining any gaps in research. Research is being conducted in a variety of areas by several research organizations to provide the necessary technical basis for implementing hydrogen blends. The status of existing projects can be found in the SoCalGas RD&D 2021 Annual Report, Appendix *2021 Summary of Ongoing and Completed Projects*.
C13	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** Given the on-going challenges associated with the Aliso Canyon Underground Storage Field, has SoCalGas considered conducting some research on alternatives to the continued use of this facility? **A:** This question falls outside the scope of the SoCalGas RD&D Program.
C14	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** I urge SoCalGas to reach out to its suppliers in the Permian Basin and the San Juan Basin to use infrared sensors (or other devices) to survey sources of methane leaks both in production areas and along El Paso, Transwestern, and Kern River's pipelines. Methane is a far more potent global warming catalyst than carbon dioxide alone and efforts to control methane leaks need to be a priority. **A:** This question falls outside the scope of the SoCalGas RD&D Program.
C15	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** Many low-income communities in Southern California are bisected by freeways and/or industrial/warehouse facilities that have substantial

	negative localized health effects on affected communities. I urge SoCalGas to reach out to its network of community-based organizations to develop local RD&D projects in these areas that will reduce GHG emissions and improve local air quality. For example, retrofitting a backup diesel generator at a local hospital with a fuel cell. **A:** Working with community-based organizations (CBOs) to develop projects that benefit our local communities is of great interest to SoCalGas RD&D. Thank you for the project suggestion.
C16	Submitter: Peggi Hazlett, **Greater Ontario Business Council** (phazlett@ontario.org) **Q:** Thank you so much for such an informative workshop recapping the past year's RD&D projects and programs for SoCalGas. I really appreciate the connection with local universities and the emerging workforce. Strategically placing these projects on campuses brings an exposure to the next generation of research employees. As I stated in my question, partnering with institutions of higher education in the Inland Empire could be a win-win for everyone! With so many challenges facing the logistics and distribution industries, the emergence of alternative fueled trucks is key. Decarbonization of GHG emissions by replacing older vehicles that are impacting our region with hydrogen cell vehicles along with electric-powered fleets needs to be in the forethought of policy makers. I found the handouts to be particularly helpful and easy to read. Thank you for that!! If there is anything that we can do at the Greater Ontario Business Council to assist SoCalGas, please let me know. **A:** Thank you for your comments and your participation in our Public Workshop.

15 Appendix D: Project Selection Process

When identifying promising projects and evaluating them for potential funding, RD&D Program staff take a comprehensive yet flexible approach that enables them to 1) identify potential projects most in alignment with RD&D Program goals, state and federal environmental policy, and industry demand; 2) accurately assess the likelihood of potential projects to succeed; 3) work with proven partners and technologies over time; and 4) respond nimbly to changing market, technology, and policy drivers. In addition—remembering that some technologies will not result in concrete benefits until implemented at scale—RD&D Program staff consider the overall development and implementation process and research life cycle of a given technology or product.

RD&D Program area staff explore a variety of avenues to identify and conceive potential projects, including:

Table 7: RD&D Program area staff explore many avenues to identify and conceive potential projects.

Addressing Internal Operations Needs	RD&D Program staff address the needs of SoCalGas operations through regular engagement with a large number of SMEs within the organization. These SMEs provide input into technology development strategies, review research proposals, and participate in RD&D Program projects by providing technical input and guidance. They also serve as the internal technical leaders in regulatory proceedings, provide awareness of industry activities, and help manage internal policies and procedures.
Addressing Customer Needs	SoCalGas Account Executives work closely with commercial and industrial customers. The Customer Strategy & Engagement group interacts with residential customers through programs such the Customer Insight Panel. These teams often bring customer challenges to RD&D Program staff, seeking to identify available products or technologies to address a need, or, if none exists, to spur research aimed at advancing or developing appropriate new technologies or products.
Literature Surveys, Conferences, and Workshops	RD&D Program staff engage in ongoing education in their areas of expertise to remain abreast of the latest technologies and research and also scout potential opportunities. They regularly read technical journals, visit national laboratories, and attend clean technology forums/webinars held by various DOE divisions, such as the Advanced Research Projects Agency-Energy (ARPA-E), Energy Efficiency and Renewable Energy (EERE), and the Office of Fossil Energy's National Energy Technology Laboratory (NETL). These activities enable them to identify the latest technology developments in their respective fields as soon as they are made available and perform detailed gap analyses to better understand which research areas merit further study and evaluation.

Research Consortia	RD&D Program staff leverage the national and international experience of other utilities through participation in industry research consortia, such as Utilization Technology Development (UTD), Operations Technology Development (OTD), NYSEARCH, and Pipeline Research Council International (PRCI). Close relationships with these organizations facilitate the generation of project ideas, development of proposals based on business value and SoCalGas ratepayer needs, enable SoCalGas to vet potential projects with industry counterparts, and provide access to significant amounts of co-funding.
External Funding Opportunities	When public agencies, such as the CEC or the DOE, release a funding opportunity, RD&D Program staff often receive proposals from third-party researchers or entrepreneurs applying to the opportunity with a request for a letter of support and/or cost share from SoCalGas. Additionally, RD&D Program staff continually track various governmental funding opportunities and leverage their existing relationships with researchers and entrepreneurs to assemble teams, develop proposals, and submit applications when funding opportunities are identified.
Proposals from Researchers	RD&D Program staff have developed a strong network of researchers throughout North America. These researchers serve as a rich source of project concepts for RD&D Program staff, who often work with the researchers to refine and improve concepts of interest and identify relevant co-funding opportunities, project demonstration sites, or strategic partners that can enhance the quality of the project and maximize potential customer benefit.
Technology Roadmap Development	RD&D Program staff often engage groups of SMEs to identify scientific and technological gaps as well as promising technology pathways in each program area. After identifying the gaps and pathways, the team recommends promising technologies that are close to demonstration or commercialization and others that are earlier in the development cycle but are likely to result in significant long-term benefits. Staff then develop a detailed long-term plan to address the gaps and demonstrate the feasibility of a selected technological pathway.
Public Workshops and Outreach	The annual RD&D Stakeholder Workshop provides a forum for many stakeholders—including private, governmental, and academic researchers, regulatory and policy staff, entrepreneurs, businesses, equity and environmental justice advocates, community-based organizations (CBOs), and the general public—to offer guidance, discuss research needs, and describe project ideas to RD&D Program staff. SoCalGas also conducts pre- and post-workshop outreach to interested stakeholders to enable longer, more thoughtful discussion about RD&D topics. RD&D Program staff also participate in panel discussions and conferences where stakeholders present project proposals or where education and engagement opportunities exist.

Policy Drivers	SoCalGas strives to align the RD&D Program with California's policy goals, including building and transportation decarbonization. RD&D Program staff leverage a network of relationships with experts at local, state, and federal agencies to track current and potential future policies and regulations in order to identify and develop project concepts to achieve these goals.

Although staff from each of the five program areas have distinct research interests, goals, and industry relationships, all follow a similar high-level approach to project identification and selection. In summary, program staff 1) identify potential areas for research, development, and demonstration and collaborate with researchers to develop project proposals; 2) prepare or receive project proposals; 3) review project proposals with the RD&D Program team and SMEs, considering a wide range of evaluation criteria and the overall portfolio strategy; 4) refine scopes of work for approved projects, if necessary; 5) allocate funding following SoCalGas accounting policies; and 6) execute the project contract and initiate project research.

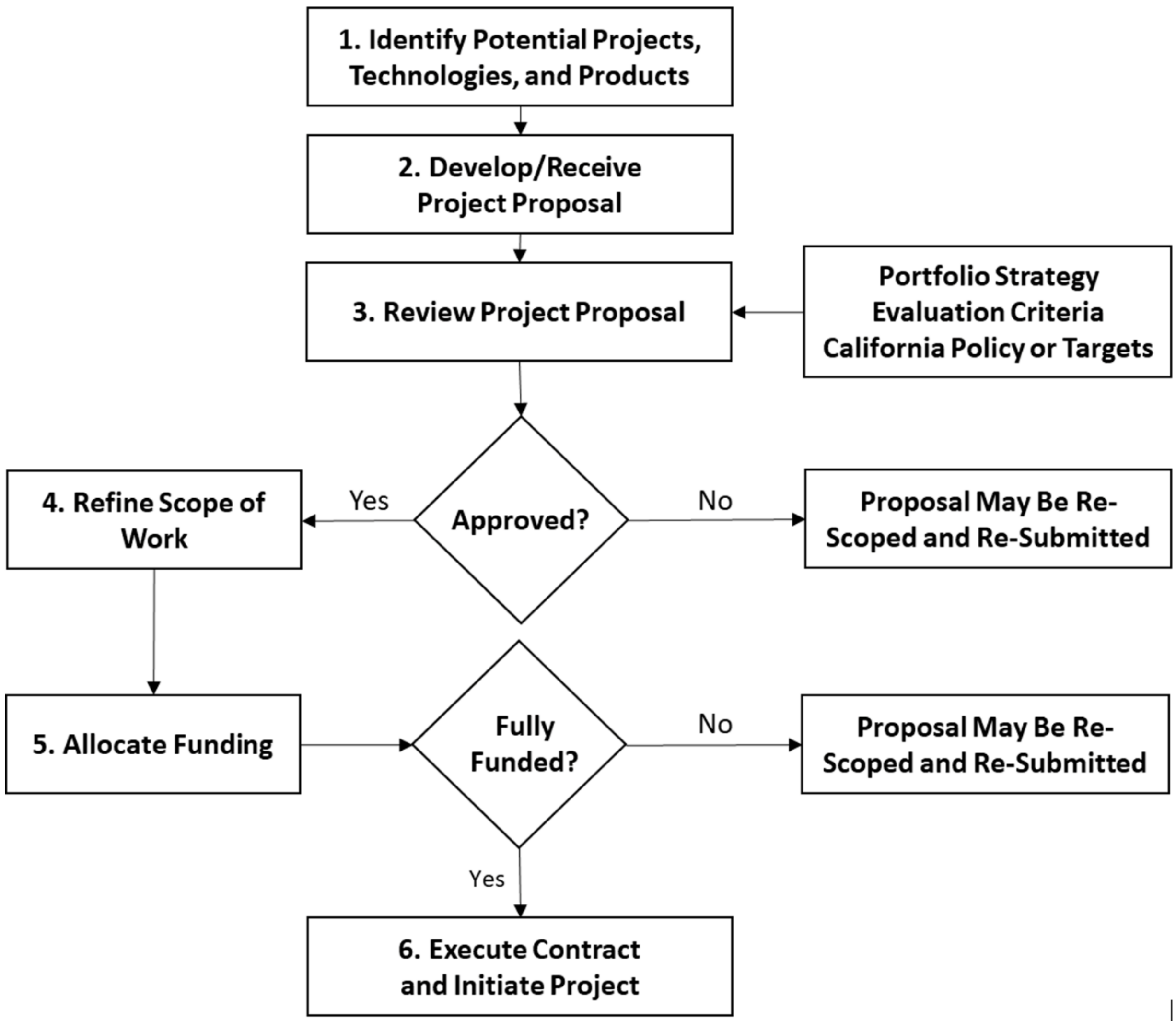


Figure 1: High-level internal RD&D project proposal review process.

During the internal project review process, RD&D Program staff evaluate potential projects using numerous selection criteria. Project selection criteria are based primarily on California Public Utility Code 740.1 which provides guidelines in evaluating the research, development, and demonstration programs proposed by electrical and gas corporations (Table 2). The criteria were also influenced by stakeholder input, industry best practices, and the RD&D staff's extensive experience evaluating research proposals. , Program staff do not numerically score potential projects or, necessarily weight the selection criteria for several reasons, including the need to retain flexibility to respond to changing market, policy and technical conditions while supporting promising projects, the diversity of types and scope of individual projects, and the variety of business needs and policy drivers.

Table 2: RD&D Program staff relied primarily on CPU Code 740.1 in developing project selection criteria.

Benefit	Relevant Section of CPU Code 740.1	Relevant Language
Customer Benefit	740.1a	"Projects should offer a reasonable probability of providing benefits to ratepayers." "Each project should also support one or more of the following objectives:
	740.1e	(1) Environmental improvement. (2) Public and employee safety. (3) Conservation by efficient resource use or by reducing or shifting system load. (4) Development of new resources and processes, particularly renewable resources and processes which further supply technologies. (5) Improve operating efficiency and reliability or otherwise reduce operating costs.".
Lead Investigator/T Eam **Technical Feasibility** **Commercializ ation Potential**	740.1b	"Expenditures on projects which have a low probability for success should be minimized."
Alignment with California Policy	740.1c	RD&D "Projects should be consistent with the corporation's resource plan." SoCalGas also considers guidance from stakeholders and regulators to ensure that projects support California's environmental goals.
Co-funding Collaborators	740.1d	"Projects should not unnecessarily duplicate research currently, previously, or imminently undertaken by other electrical or gas corporations or research organizations."

Equity	N/A	SoCalGas included equity in response to feedback from multiple stakeholders and regulators and was guided in part by the CPUC's ESJ Action Plan.

The 2023 project selection criteria are as follows:

Criteria	Description/Justification
Customer Benefit	RD&D Program staff also seek to advance a significant portion of the products, technologies, and solutions they help develop to the point where they can be implemented by SoCalGas and other utilities for the benefit of ratepayers. To assess this criterion, RD&D Program staff ask questions such as: Will advancing the proposed technology benefit gas utility ratepayers? If the technology becomes commercially available, how will it help SoCalGas customers, as well as internal (i.e., RD&D Program operations teams) and external stakeholders in a meaningful way? Does the technology address a key policy driver relevant to the SoCalGas service territory? Is the research new and not duplicative of previous or ongoing work by other research and development (R&D) organizations?
Alignment with California Policy	The RD&D team also seeks to align its program with key company, state, and federal objectives. To assess this criterion, RD&D staff ask questions such as: Does the project address a key California state policy driver or corporate initiative? Does the project advance the state of the technology along a development roadmap? Does the research address an internal operational need?
Lead Investigator/Team	Successful R&D Program teams need industry knowledge and technical skills to succeed, but they must balance these characteristics with soft skills, such as curiosity, perseverance, people management, and critical and strategic thinking. To assess this criterion, RD&D Program staff ask questions such as: Are the researchers, labs, or technology developers skilled and experienced in the space? Do they have a track record of success in executing research projects of a similar scope and successfully leading research teams? Do they have unique capabilities or facilities for conducting the required research? Do they have the skills and resources necessary to commercialize the proposed new technology?
Technical Feasibility	Although the RD&D Program team funds early-stage RD&D Program projects, it has a responsibility to ratepayers to fund projects with a high likelihood of success. To assess this criterion, RD&D Program staff ask questions such as: Has the technology been vetted internally or externally for

	feasibility? Is the basic science sound? Does the technology display favorable thermodynamic modeling or technoeconomic fundamentals? Does documentation of proof-of-concept work exist?
Co-funding Collaborators	One of the key objectives of the RD&D Program is to leverage the funds it uses to support promising projects with significant additional funding from other organizations, such as public agencies, universities, and private businesses. In fact, in 2021, every dollar of RD&D Program funds expended was matched by an average of $5.20 in funding from other sources. To assess this criterion, RD&D Program staff ask questions such as: Are other R&D programs, government agencies, or industrial entities collaborating on the project, either via co-funding or time and expertise? Can co-funding collaborators help validate and substantiate the feasibility of the technical claims? Is co-funding available to leverage the RD&D Program funding? Are other stakeholders supportive of the research? Is there consortium involvement to minimize the risk of duplicating work?
Commercialization Potential	Ultimately, RD&D Program staff seek to advance a significant portion of the products, technologies, and solutions they help develop to the point where they can be advanced to market in support of energy decarbonization, safety, and reliability. To assess this criterion, RD&D Program staff ask questions such as: Does the proposed level of funding match the technology readiness level (TRL)? Does a clear path to commercialization exist for the technology that this research advances? Is there immediate and anticipated future demand for the proposed technology based on defined market trends and competitive advantages in comparison to the status quo or alternative technologies? Does the project team bring sufficient financial support to the project to fund multiple years of development runway? Is the project team working with established commercialization experts who have proven track records with similar products or technologies?
Equity Considerations	The RD&D Program seeks to advance and champion products and technologies that support widespread access to clean, affordable, and renewable energy for all Californians, including those living and working in Environmental and Social Justice (ESJ) communities. To assess this criterion, RD&D Program staff ask questions such as: Does the proposed technology directly address the specific needs of a Disadvantaged Community (DAC) or Low-Income Community (LIC)? Is the project sited near a DAC or LIC? Does the project include engagement by a

	Community Based Organization (CBO) or Diverse Business Enterprise (DBE)? Is the Principal Investigator (PI) a member of an underrepresented population?

16 Appendix E: Project Details

The project data provided is a current snapshot of the RD&D project portfolio including all current projects that are multi-year continuing from 2022 into 2023 updated as of November 30, 2023.
For clarity, we have mapped our data response to 16 data fields described in the Discussion sub-section titled *Detailed budgets broken down by research subprogram* of the resolution. Additional data fields have been added to address the requirements of Resolution G-3601.

a) **Project title**
b) **Unique number identifier for project**
c) **Program and sub-program**
d) **Project Start date**
e) **Project end date or anticipated end date**
f) **SoCalGas budget for project**
g) **Total cost contracted**
h) **Amount already spent**
i) **Amount still to be spent**
j) **Co-funding partners**
k) **Monetary contribution of each co-funding partner**
l) **Project benefits of research**
m) **Research area**
n) **Technology readiness level**
o) **Next steps at end of project**
p) **One-paragraph narrative description**
q) **Actual Incurred Cost Jan-Nov '23**
r) **Status**
s) **Estimated Incurred Cost Jan-Nov '23**
t) **Hydrogen Blend Projects**

ATTACHMENT B

Advice No. 6273-G

Track-change version – SoCalGas Research, Development and Demonstration Program REVISED 2023 Research Plan

RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAM

REVISED 2023 RESEARCH PLAN

ORIGINAL SUBMISSION: JUNE 15, 2022
REVISED SUBMISSION: MARCH 3, 2024

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“The future is very bright. Humanity has important problems to solve but we are better positioned to solve them than at any other time in history. To help build a decarbonized energy system for California, SoCalGas is overcoming challenges, implementing solutions, and collaborating with innovative partners so every Californian can have access to clean, reliable, and affordable energy.”

—**Maryam Brown**
President
SoCalGas

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TABLE OF CONTENTS

ACRONYMS

Acronym	Description
AB	Assembly Bill
AI	Artificial Intelligence
ARPA-E	Advanced Research Projects Agency-Energy
BETO	Bioenergy Technologies Office
BTU	British Thermal Unit
CARB	California Air Resources Board
CAV	Connected and Autonomous Vehicle
CBO	Community-based Organizations
CCS	Carbon Capture and Sequestration
CCST	California Council on Science and Technology
CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Utilization, and Sequestration
CEC	California Energy Commission
CFR	Code of Federal Regulations
CFS	Commercial Food Service
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CNTP	Catalytic Non-Thermal Plasma
CO_2	Carbon Dioxide
CPUC	California Public Utilities Commission
CRH	Clean Renewable Hydrogen
CSP	Concentrated Solar Power
CSU	California State University
CTP	Clean Transportation Program
DAC	Disadvantaged Community
DBE	Diverse Business Enterprise
DG	Distributed Generation
DME	Dimethyl Ether
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EERE	Energy Efficiency and Renewable Energy
EMAT	Electromagnetic Acoustic Transducer
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPIC	Electric Program Investment Charge
ESJ	Environmental and Social Justice
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FCTO	Fuel Cell Technologies Office
GHG	Greenhouse Gas

GRC	General Rate Case
GTI	GTI Energy (formerly Gas Technology Institute)
HFCV	Hydrogen Fuel Cell Vehicle
IoT	Internet of Things
IOU	Investor-Owned Utility
IPCC	Intergovernmental Panel on Climate Change
LCFS	Low Carbon Fuel Standard
LIC	Low-Income Community
MHD	Medium- and Heavy-Duty
MSS	Mobile and Stationary Source
NAACP	National Association for the Advancement of Colored People
NDE	Nondestructive Examination
NETL	National Energy Technology Laboratory
NGA	Northeast Gas Association
NGRP	Natural Gas Research Program
NGV	Natural Gas Vehicle
NREL	National Renewable Energy Laboratory
OIR	Order Instituting Rulemaking
OTD	Operations Technology Development
PE	Polyethylene
PM	Particulate Matter
PNNL	Pacific Northwest National Laboratory
PRCI	Pipeline Research Council International
PSPS	Public Safety Power Shutoff
R&D	Research and Development
RD&D Program	SoCalGas' Research, Development, and Demonstration Program
RNG	Renewable Natural Gas
RPA	Regional Public Affairs
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
SCF	Standard Cubic Foot
SJVAPCD	San Joaquin Valley Air Pollution Control District
SME	Subject Matter Expert
SMP	Sustaining Membership Program
SMR	Steam Methane Reforming
SoCalGas	Southern California Gas Company
SOFCS	Solid Oxide Fuel Cells
T&D	Transmission and Distribution
TAP	Technology Advancement Program
TCO	Total Cost of Ownership
TRL	Technology Readiness Level
UIAF	Uniform Impact Analysis Framework

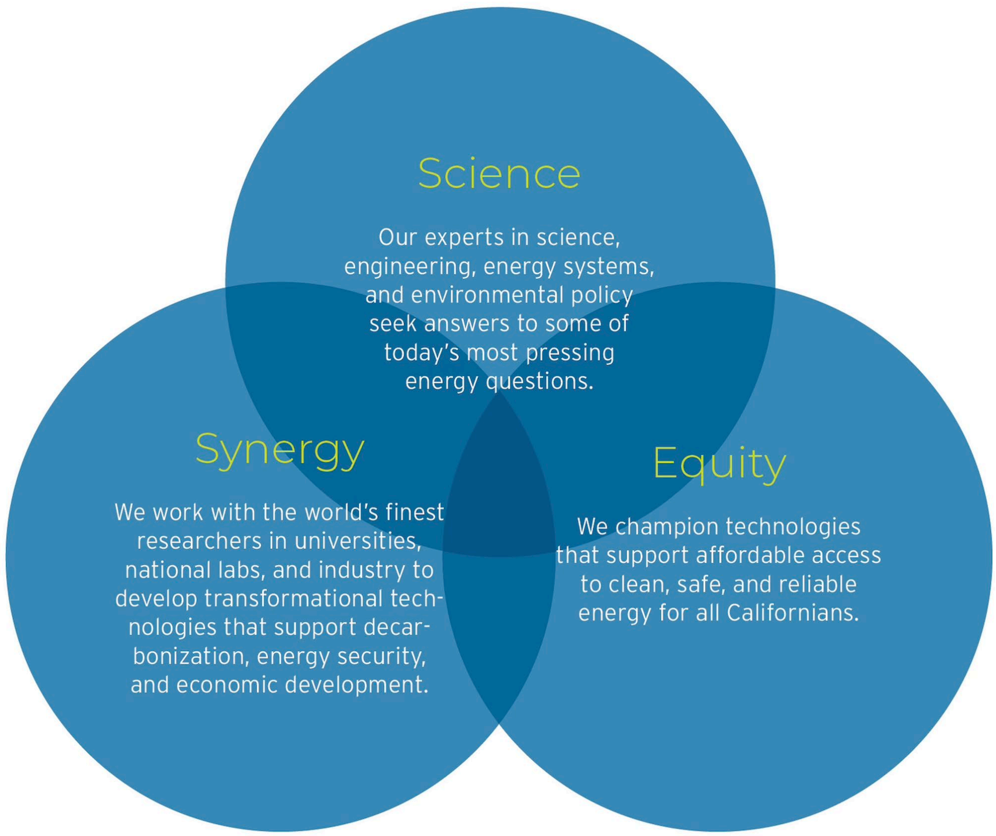
UC	University of California
UTD	Utilization Technology Development
VOC	Volatile Organic Compound
ZEV	Zero-Emission Vehicle

1 Overview

SoCalGas Research, Development, and Demonstration (RD&D) plays a key role in the company's efforts to achieve net zero greenhouse gas (GHG) emissions in its operations and delivery of energy by 2045. In collaboration with professionals from the world's top institutions, RD&D staff develop and demonstrate transformational products and technologies that promote decarbonization across the natural gas value chain and a diversified portfolio of clean, reliable, safe, and affordable energy sources.

Table 1: The vision, mission, and values of the RD&D Program align with the SoCalGas mission to build the cleanest, safest, and most innovative energy company in America.

VISION	MISSION
Advancing innovative technologies for safer, cleaner, and more reliable energy.	Identify transformational energy solutions. Build them. Share them with the world.
VALUES	



SoCalGas RD&D is staffed with subject matter experts (SME) in science, engineering, industrial process technology, and environmental policy. Every year, RD&D staff support hundreds of projects along the commercialization pathway—from lab-scale research and development (R&D) to multi-year precommercial demonstrations—with the ultimate goals of saving energy, reducing GHG emissions, improving air quality, and increasing the safety, reliability, and affordability of energy.

In 2021, SoCalGas RD&D provided technical assistance, outreach, strategic guidance, and almost $17 million in funding to 379 projects throughout California and around the nation. In 2023, RD&D Program staff anticipated spending a total of $16,874,000 supporting hundreds of projects. Modifications to this Revised Plan are detailed below in accordance with the issuance of California Public Utilities Commission (CPUC) Resolution (Res.) G-3601.

1.0 Revised RD&D 2023 Research Plan Pursuant to Res. G-3601

1.0.1 Background and Summary

SoCalGas RD&D submitted its initial 2023 RD&D Research Plan to the CPUC in Advice Letter (AL) 5991-G on June 15, 2022,[1] based on and consistent with the direction provided in Res. G-3586. In its initial submission, SoCalGas proposed to record up to $16.874 million to its RD&D Expense Account, describing how it would allocate RD&D funds into its seventeen subprograms and program administration.

On November 30, 2023, the CPUC issued Res. G-3601 approving, in part, the funding allocation proposed by SoCalGas in AL 5991-G. In Res. G-3601, the CPUC directed SoCalGas to modify the 2023 RD&D Research Plan and submit a revised proposal for reallocating denied funding allocations through a Tier 2 Advice Letter. Pursuant to these directives, the primary modifications included in the revised 2023 RD&D Research Plan are:

- Retirement of eight subprograms: Carbon Capture, Utilization, and Sequestration, Off-Road, Onboard Storage, On-Road, Refueling Stations, Distributed Generation, Industrial Process Heat, and Residential Appliances. Funds initially allocated under these subprograms are proposed to be reallocated to other subprograms including those approved and directed for consideration by Res. G-3601. In the revised 2023 Research Plan, each of the subprograms' Funding Allocation table reflects this redistribution.

- How SoCalGas proposes to demonstrate how its hydrogen programs and projects will utilize clean, renewable hydrogen (CRH), consistent with the definition given in Decision (D.) 22-12-057.

- Supplemental information in Appendix E about blending projects that are carried under the System Inspection and Monitoring subprogram, including highlighting aspects that demonstrate how those projects complement and support the efforts under the hydrogen blending pilots conducted through D.22-12-057 without being duplicative.

- Expansion of the Equity section of the Revised 2023 RD&D Research Plan to provide greater detail about how SoCalGas's proposed projects and strategies benefit Environmental and Social Justice (ESJ) communities. Additional information is also being provided about the development of its impact analysis framework and how it plans to incorporate guidance from the Uniform Impact Analysis Framework efforts in Res. 19-10-005.[2]

[1] https://tariff.socalgas.com/regulatory/tariffs/tm2/pdf/submittals/GAS_5991.
[2] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M507/K499/507499284.PDF

- Supplemental information about RD&D participation in consortiums including justification of consortium dues to clarify how these efforts can benefit ratepayers.

All revisions to the initial 2023 RD&D Research Plan associated with Res. G-3601 are specifically identified under Revisions pursuant to Res. G-3601 throughout this document and redlined as directed.

1.1 RD&D Program Goals and Structure

The goals of the RD&D program are to identify, test, and commercialize transformational new energy technologies that will reduce GHG and criteria air pollutant emissions, maintain the energy affordability that natural gas has historically provided, and advance the safety and reliability of California's gas delivery networks and systems in an ever-changing operational environment.

SoCalGas RD&D is divided into five programs, each of which is focused on products and technologies united by a broad theme such as transportation or end-use applications. Programs remain constant from year to year.

Each program is, in turn, broken into multiple subprograms. Each subprogram focuses on a subset of the program theme. Subprograms remain relatively constant but can change in response to industry developments, guidance from the California Public Utilities Commission (CPUC), or stakeholder input.

Each subprogram includes several research areas. These forward-looking categories suggest the types of projects RD&D hopes to fund. Staff evaluate research areas annually. Research areas are non-exhaustive; RD&D can and does fund or otherwise support projects that do not fall within a defined research area.

In 2023, SoCalGas RD&D intends to allocate funding across five programs—Low Carbon Resources, Gas Operations, Clean Transportation, Clean Generation, and Customer End-Use Applications—and multiple associated subprograms.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring eight subprograms in 2023: Carbon Capture, Utilization, & Sequestration, Off-Road, Onboard Storage, On-Road, Refueling Stations, Distributed Generation, Industrial Process Heat, and Residential Appliances. For each of these retired subprograms, SoCalGas is designating as "Actual Incurred Cost" those costs incurred and paid by RD&D in 2023 up to the issuance of G-3601 for work in multi-year agreements that were executed before Dec 31, 2022. SoCalGas also provides "Estimated Incurred Costs" for multiyear agreements in which costs were incurred up to the issuance of G-3601, but an invoice has not yet been received and/or paid, which are also proposed to be allocated as shown in the revised funding allocation table for each of these subprograms. Remaining funds under each retired subprogram that have not been previously incurred are shown as "Funds Available for Reallocation" and are distributed to different subprograms approved by Res. G-3601. More information is provided in the revised Section 6 – Proposed 2023 Funding Allocations.

Table 2: The RD&D Program is divided into five programs and 17 subprograms.[3]

Programs	Subprograms
Low Carbon Resources	Carbon Capture, Utilization, & Sequestration (Retired)
	Renewable Gas Production
Gas Operations	Environmental & Safety
	Operations Technology
	System Design & Materials
	System Inspection & Monitoring
Clean Transportation	Off-Road (Retired)
	Onboard Storage (Retired)
	On-Road (Retired)
	Refueling Stations (Retired)
Clean Generation	Distributed Generation (Retired)
	Integration & Controls
Customer End-Use Applications	Advanced Innovation
	Commercial Applications
	Commercial Food Service
	Industrial Process Heat (Retired)
	Residential Appliances (Retired)

Within each sub-program, RD&D Program staff take a comprehensive yet flexible approach when identifying promising projects and evaluating them for potential funding. This approach enables them to 1) identify potential projects most in alignment with RD&D Program goals, state and federal environmental policy, and industry demand; 2) accurately assess the likelihood of potential projects to succeed; 3) work with proven partners and technologies over time; and 4) respond nimbly to changing market, technology, and policy drivers. More details about the Project Selection Process and Evaluation Criteria can be found in Appendix D of this document.

[3] Retired subprograms are those that were ongoing and are now being retired pursuant to the CPUC's directives in Res. G-3601.

2 Regulatory and Policy Drivers

RD&D staff consider a variety of factors in determining how to broadly allocate funding. These factors include regulatory and policy drivers, input from knowledgeable stakeholders, input from the California Public Utilities Commission (CPUC) Energy Division staff and other interested parties at an annual workshop, and the potential impact of research on environmental and social justice (ESJ) communities. The process is designed to optimize subprogram-level funding allocations, to provide an opportunity for stakeholder input, and to maximize progress toward overarching program goals and objectives.

Table 3: Key state and federal policies and regulations impacting SoCalGas RD&D.

Category	Regulations and Policy Drivers
GHG Emissions	**AB 32:** Reduce carbon dioxide (CO_2) emissions 40% below 1990 levels by 2030 **SB 100:** Zero-carbon electricity by 2045 **EO B-55-18:** Carbon-neutral California economy by 2045 **AB 3232:** Reduce GHG emissions from residential and commercial buildings by 40 below 1990 levels by 2030 **SB 1101:** Carbon Sequestration: Pore Space Ownership and Carbon Capture, Utilization, and Storage Program
Pipeline Safety	**CPUC General Order 112F:** Rules governing design, testing, operation, and maintenance of gas transmission and distribution (T&D) systems **U.S. Department of Transportation (DOT) 49 Code of Federal Regulations (CFR) Part 192:** Federal pipeline safety regulations **AB 1900:** Biomethane quality standards **Order Institute Rulemaking (OIR) R.13-02-008, Phase 4:** Addresses injection of renewable hydrogen into gas pipelines
Local Air Quality	**Clean Air Act:** Air quality standards for nitrogen oxides (NOx) and particulate matter (PM) **AB 617:** Nonvehicular air pollution: criteria air pollutants and toxic air contaminants
Clean Transportation	**ARB Implementation Plan:** Low-NOx standard for trucks **AB 8:** Development of 100 hydrogen fueling stations in California **EO B32-15:** Sustainable freight action plan **EO B48-18:** 200 hydrogen refueling stations by 2025 **EO N-79-20:** 100% of MHDs be zero emission by 2045 for all operations where feasible **Low Carbon Fuel Standard (LCFS):** Reduce carbon intensity of fuels by 10% by 2020 **SB 1275:** One million zero-emission and near-zero-emission vehicles by 2023

Equity	**General Order 156:** Encourages investor-owned utilities (IOUs) to procure or contract goods and services from women-, minority-, disabled veteran- and/or LGBTQ-owned business enterprises **CPUC ESJ Action Plan:** Increase investment in clean energy resources to benefit ESJ communities, especially to improve local air quality and public health
Methane Emissions	**SB 1383:** Reduces methane emissions from decomposition of organic wastes **SB 1440:** Authorizes a state procurement program for biomethane **CARB Oil and Gas Rules:** Requires new monitoring and repairs to reduce methane emissions **Natural Gas STAR Program:** Encourages adoption of methane-reducing technologies and practices **EPA Methane Challenge Program:** Recognizes oil and gas companies that take comprehensive action to reduce methane emissions

3 Stakeholder Input

3.1 Stakeholder Outreach

SoCalGas RD&D works closely with industry professionals and SMEs at universities, national labs, public agencies, businesses, and industry research consortia to maximize the impact of its funding of promising technologies and products focused on producing or delivering cleaner, safer, affordable, and more reliable energy. These relationships enable SoCalGas to engage with science and technology experts, other utilities, and industry stakeholders to effectively identify and close knowledge and research gaps, avoid duplication of previous and ongoing research, and reduce technology and commercialization risks to achieve the goals of SoCalGas RD&D.

Conversations with these stakeholders and SMEs are ongoing throughout the year, but in preparation for the 2023 funding allocations, RD&D Program staff also conducted a series of targeted interviews with 15 people from 11 different organizations in the first quarter of 2022. During these interviews, the SMEs and industry stakeholders were asked a series of standard questions and then engaged in a freeform discussion about the industry and its RD&D needs. See Appendix A for a summary of responses.

Table 4: RD&D Program staff conducted stakeholder interviews with 15 individuals from 11 different organizations in early 2022.

2022 Stakeholder Organizations Interviewed

Bakersfield College	National Renewable Energy Laboratory
California Energy Commission	Northeast Gas Association/NYSEARCH
California State University, Long Beach	Pipeline Research Council International
California State University, Los Angeles	Stanford Natural Gas Institute
GTI Energy	U.S. Department of Energy

Kern Oil

3.2 Annual Stakeholder Workshop

On April 27, 2022, SoCalGas RD&D hosted an online workshop to present the results of the previous year's program and obtain input regarding proposed spending allocations for 2023. SoCalGas RD&D staff publicly announced the workshop on the SoCalGas RD&D website and LinkedIn page and by email to members of the A.17-10-008, R.19-10-005, R.20-01-007, R.19-01-011, and R.13-11-005 service lists.

248 individuals from a wide variety of organizations attended the workshop. Organizations sending attendees included four national laboratories, four public agencies, and numerous industry organizations, universities, community-based organizations (CBOs), and private companies.[4]

2022 Annual Stakeholder Workshop Attendee List

Accenture	Global Water Advisors, Inc.
Agility	Greater Ontario Business Council
Air Products and Chemicals, Inc.	Green Impact Partners
Alexander Talks	Gregori Consulting LLC
Allawos & Company	Gridworks
Alliance North America	GTI Energy
American Gas Association	H2 Energy Group, Inc.
ANGI Energy Systems	H2U Technologies
Argonne National Laboratory	Heliogen
AISIN Corporation	Hermandad Mexicana Nacional
Aspen	Home Energy Analytics, Inc.
ATCO Ltd.	Hy Stor Energy
Berokoff Energy Solutions	Hyperlight Energy
BEST LLC	Hyteon, Inc.
Brubaker & Associates, Inc.	Immaterial Ltd.
Burns & McDonnell	InterAct PTMI
California Energy Commission	Jay Luboff Consulting LLC
California Fuel Cell Partnership	Los Angeles Department of Water and Power
California Institute of Technology	Mar Vista Family Center
California League of Food Producers	Massachusetts Hydrogen Coalition
California Public Utilities Commission	MCE Clean Energy
California State University, Los Angeles	Mehta Associates
Calpine Corporation	Middle River Power LLC
Capgemini	Momentum
Capstone Green Energy	NASA Jet Propulsion Laboratory
Chevron	National Grid
Clean Energy	National Renewable Energy Laboratory
Custom Alloy Sales, Inc.	Nel Hydrogen
DAC	New Jersey Natural Gas

[4] To encourage participation by CBOs, RD&D provided stipends to several to cover their time attending the workshop.

Del Rey Consultancy	New York State Electric & Gas Corporation
Department of Energy, Hydrogen & Fuel Cell Technologies	NGVAmerica
E2 Consulting Engineers, Inc.	Northridge East Neighborhood Council
EEG Energy Gas	Northwest Energy Efficiency Alliance
Electric Power Research Institute, Inc.	NW Natural Gas Co.
Energy Capital Ventures	NYSEARCH/Northeast Gas Association
ENGIE	Oak Ridge National Laboratory
Florence Firestone Merchants Association	OMC Hydrogen, Inc.
FM Global Holdings	Osaka Gas USA
Frontier Energy	Pacific Gas & Electric
FuelCell Energy, Inc.	Pacific Northwest National Laboratory
Galileo Technologies	Palo Alto Research Center
Gazomat	Peoples Gas
GenCell Energy	Plains Midstream Canada
General Motors	Quaise Energy Limited
GKN Hydrogen	RealEnergy

3.3 Stakeholder Input

During the five-hour workshop, RD&D team members presented the following topics:

- 2021 in Review
- Program Status and Updates for 2022
- Draft Research Plan for 2023

At the end of each section of the presentation, the RD&D team fielded questions and comments from attendees. SoCalGas also posted a link to the workshop recording on the SoCalGas RD&D web page.[5] A complete list of the questions received during and following the workshop, along with answers from appropriate SoCalGas personnel, is included in Appendix B and Appendix C. See also Section 5.1 for more information about the response of SoCalGas RD&D to stakeholder input.

[5] https://www.socalgas.com/sustainability/research-development-demonstration-rdd

4 Equity

4.1 Environmental and Social Justice Communities and Climate Change

In California, millions of people live and work in areas categorized as ESJ communities, a designation that includes disadvantaged communities (DACs), tribal lands, and low-income households and census tracts. All too often, people from ESJ communities suffer disproportionate environmental and socioeconomic impacts, including poverty, high unemployment, air and water pollution, and high incidences of asthma and heart disease. In many cases, ESJ community residents also suffer from reduced or less reliable access to energy. What energy they can access often represents a burdensome percentage of their household incomes.[6]

Critically, members of ESJ communities are at greater risk from the negative impacts of climate change. According to the Fourth National Climate Assessment:

> *Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.*[7]

Further:

> *Impacts within and across regions will not be distributed equally. People who are already vulnerable, including lower-income and other marginalized communities, have lower capacity to prepare for and cope with extreme weather and climate-related events and are expected to experience greater impacts. Prioritizing adaptation actions for the most vulnerable populations would contribute to a more equitable future within and across communities. Global action to significantly cut greenhouse gas emissions can substantially reduce climate-related risks and increase opportunities for these populations in the longer term.*[8]

4.2 Diversity, Equity, and Inclusion at SoCalGas

SoCalGas is committed to equity, diversity, and inclusion. SoCalGas is an Affirmative Action and Equal Employment Opportunity employer and considers all applicants for employment without regard to race, color, religion, sex, gender identity, gender expression, sexual orientation, national origin, age, handicap or disability status, or status as a protected veteran under state and federal law.

In 2021, the company awarded $972.6 million in SoCalGas contracts—a 10% increase over 2020 and the highest total in SoCalGas history—to 577 certified Diverse Business Enterprises (DBEs). This represents 42.42% of the company's total purchases with suppliers.[9] Importantly, this total marks the 29th consecutive time that SoCalGas

[6] https://www.energy.gov/sites/prod/files/2019/01/f58/WIP-Energy-Burden_final.pdf
[7] https://nca2018.globalchange.gov/#
[8] https://nca2018.globalchange.gov/#
[9] https://www.socalgas.com/for-your-business/supplier-diversity

exceeded the CPUC's goal of 21.5% of total procurement of goods and services from women, minority, service-disabled veteran, and LGBTQ-owned businesses.

The company is also actively fulfilling the commitments of the CEO Action for Diversity & Inclusion, a pledge by more than 900 companies worldwide to advance diversity and inclusion in the workplace. To reinforce the SoCalGas vision of a workplace where everyone feels like they belong and are able to thrive, the company's Diversity & Inclusion department offers several ways for employees to be involved, including:

- Five Diversity & Inclusion Councils
- A Diversity & Inclusion Mentoring Program
- An Annual Diversity & Inclusion Summit
- Affinity groups for Black and Latino employees
- The VALOR program that helps provide a smooth transition for newly hired SoCalGas veteran/active military employees

SoCalGas believes in not only lending a hand, but also empowering people with a hand up, so they can further develop, grow, and subsequently empower others. The company's goal is to focus on charitable giving initiatives that create positive ripple effects throughout the community we serve and truly make a better world. Recently, the SoCalGas Charitable Giving Report was converted into a quarterly video and magazine series entitled *Empower*,[10] where stakeholders can learn more about the diverse personal human impacts that our charitable initiatives create.

4.3 Equity in SoCalGas RD&D

Equity is one of the program's core values and a factor it considers in every funding allocation decision. SoCalGas RD&D seeks to advance and champion technologies that support widespread access to clean, affordable, and reliable energy for all Californians, including those living and working in ESJ communities. To achieve these goals, SoCalGas RD&D:

- Seeks to locate projects in under-resourced communities
- Supports diverse research teams that include members from disadvantaged and underrepresented groups
- Shares the results from RD&D projects to inform and educate the public
- Reports its progress in diversity and inclusion efforts in its Annual Report

SoCalGas RD&D also regularly engages with diverse academic populations at universities and colleges to foster new researchers. Examples of this activity include:

- **Cal State LA Engineering, Computer Science, & Technology Capstone Senior Design Program**
  Cal State LA is a public university known for serving numerous Hispanic, Asian American, Pacific Islander, and minority students. Many are from low-income families and are the first in their families to attend college. The university is ranked number one in the nation for upward mobility, in part due to programs such as its Engineering, Computer Science, & Technology Capstone Senior Design

[10] https://www.socalgas.com/our-community/empower

Program. Each year, funded by corporate and university sponsorships, the program gives students open-ended, real-world problems to solve. Working in small groups, the students meet with faculty advisors and project sponsors, work collaboratively, learn new skills, and present their results to faculty and sponsors. ~~SoCalGas RD&D has provided and continues to provide financial and technical support to the program since [YEAR].~~ See page 17 of the SoCalGas RD&D 2021 Annual Report for a relevant case study.

- **Community Outreach**
  On August 25, 2021, SoCalGas RD&D hosted representatives from Cypress College, Pasadena City College, Santa Barbara City College, Kern Community College District, East Los Angeles College Engineering & Technologies, Bakersfield College, Cerritos Community College, and Saddleback College. RD&D staff sought to understand how the program could help the participants meet their goals and solicited input on their key concerns, including energy affordability, safety, air quality, and emissions.

- **H2GP: Horizon Hydrogen Grand Prix**
  With support from numerous corporate sponsors, Horizon Educational conducts a global competition among high school students seeking to design and build a hybrid car powered by a hydrogen fuel cell. Representatives from SoCalGas RD&D have served as judges for the competition in the past. In 2022, SoCalGas plans to sponsor teams, with a particular focus on schools located in under-resourced communities.

SoCalGas RD&D also solicits input from community-based organizations and seeks to incorporate input from them into its planning efforts. For example, on February 24, 2021, SoCalGas RD&D met with representatives from Home Aid Orange County, Proteus Inc., Pomona Chamber of Commerce, Unity Shoppe Santa Barbara, Santa Barbara Zoo, Southeast Community Development Corporation, Family Assistance Ministries, El Concilio Family Services, and Family Service Association. RD&D Program staff presented material about new technologies with the potential to benefit disadvantaged communities and priority populations. Attendees raised concerns about energy reliability and its relation to storing medications or preparing meals. Affordability of both energy and the new technologies was a key concern.

Revisions pursuant to Res. G-3601:

SoCalGas proposes to conduct a series of studies, in coordination with Energy Division staff and the ESJ Advisory Panel, to continue to build upon existing efforts, including the RD&D's Equity Engagement Roadmap (EER), addressing the needs of the ESJ communities that contribute to the RD&D program. These studies would be designed to determine, either through literature review or primary research, the customer composition in these communities (e.g., residential, commercial, or industrial), the priorities of the members of these communities within the SoCalGas service territory, technical data (e.g., type and vintage of equipment deployed, types of vehicles owned or operated in the community, and air pollution sources within these communities), and demographic data (e.g., household income, vocations, and housing type).

This information would help RD&D to develop a plan that can focus on the key issues impacting these more vulnerable communities. RD&D proposes to present the plan to the ESJ Advisory Panel and other stakeholders (e.g., Energy Divisions staff and CEC staff) for feedback and input before implementation.

Furthermore, RD&D anticipates integrating this information into a specific set of requirements within the Uniform Impact Analysis Framework (UIAF) to address the specific needs of ESJ communities within SoCalGas' service territory.

4.4 Equity Engagement Roadmap Update

Disenfranchised communities are often left out of the decision-making process. This can result in ill-fated policy and implementation efforts that do not address their actual needs. To effectively engage with historically underserved communities, better understand their needs, and improve its operational response to these needs, SoCalGas RD&D began development of a multi-year public-facing Equity Engagement Roadmap in 2021. To develop this plan, SoCalGas RD&D has completed the following activities:

- Engaged with 2020Vet, a woman- and veteran-owned consulting firm to help develop the roadmap.
- Conducted a literature review of more than 50 ESJ documents, NGO publications, and academic reports produced by federal, state, and local government, private industry, and utilities. Among these documents was the CPUC's ESJ Action Plan.
- Identified general themes and industry best practices.
- Developed three key themes for the roadmap:
    - Obtain situational awareness
    - Increase community engagement
    - Institutionalize equity engagement
- Developed a draft plan with RD&D action items to address the key themes.
- Coordinated with 2020Vet to seek input from ESJ and diversity, equity, and inclusion (DE&I) experts and incorporated feedback into the draft plan.

In August 2023, SoCalGas RD&D issued an updated version of its Equity Engagement Roadmap, or EER.[11] The EER identified three themes and six specific tasks to guide RD&D's ongoing engagement efforts and to develop, update, and track equity engagement metrics that SoCalGas leadership, the CPUC, and the public can use to evaluate the degree to which the projects supported by SoCalGas RD&D address inequities related to climate, income, and race/ethnicity, age, and other diversity dimensions in the communities served by SoCalGas.

Task 1 of the EER guides RD&D to "Monitor and report key RD&D Equity Engagement project metrics in the RD&D Annual Report." As part of this task, the 2022 RD&D Annual

[11] https://www.socalgas.com/sites/default/files/2023-08/SoCalGas_RDD_Equity_Engagement_Roadmap.pdf.

Report[12] (and the Spanish version, "2022 Informe Annual"[13]) include a map of RD&D projects located in ESJ Communities. In 2022, 61 RD&D projects were located in ESJ Communities.

Task 6 of the EER guides RD&D to "review/revise RD&D project policies to include DEI components." As part of this task, RD&D updated its project evaluation process to include "Equity Component" field in the project description as well as to add "Equity Consideration" to the list of project evaluation criteria. These additions are designed to encourage RD&D and the research project teams to consider adding components to project scopes to consider environmental justice communities, enhance community engagement, and improve diversity of research teams.

Examples of these additions include:

- The scope of work (SOW) for the project, "GTI Energy Mobile Hydrogen Fuel Cell Generation System Demonstration (CEC MORBUGS)," includes a task to engage disadvantaged, low-income, and Tribal community stakeholders to raise their awareness of the benefits of the technology as well as increase their participation in the RD&D activity within their neighborhoods.
- The SOW for the project, "NREL Grid Forming Inverters for Fuel Cells Research," instructs NREL to create a subcontract with a university partner to support the fuel cell modeling efforts and diversity, equity, and inclusion (DEI) efforts. In support of this requirement, UCI hosted two high school outreach projects in 2023.
- The SOW for the project, "GTI Hydrogen Blend Burner Design Analysis and Guidelines Research," includes a task directing the project team to survey the types of gas appliances found in Disadvantaged Communities in SoCalGas' service territory and collect information about the community members' current knowledge, impression, and concerns hydrogen-blended gas deployment.

The results of these project components will be included in the final reports produced by each project and made available to the public. In response to OP 3.d, SoCalGas will work to include these ESJ focused project components and any available results in future Annual Reports to the Commission.

~~Moving forward, SoCalGas RD&D will pursue the following next steps:~~

- ~~Complete internal review of the draft plan~~
- ~~Seek public stakeholder input for the draft plan and incorporate feedback~~
- ~~Finalize the plan and share it with public stakeholders~~

~~SoCalGas RD&D anticipates finalizing the Equity Engagement Roadmap in 2022.~~

To better measure the impact of RD&D projects on disadvantaged and low-income communities in terms of job creation and other economic development, SoCalGas RD&D is working closely with the Energy Division of the California Public Utilities Commission to develop suitable metrics and an evaluation framework (see Section 5.2).

[12] https://www.socalgas.com/sites/default/files/2022_SoCalGas_RDD_Annual_Report.pdf#page=[17]
[13] https://www.socalgas.com/sites/default/files/2022_SoCalGas_RDD_Informe_Anual.pdf#page=[17]

On July 29, 2022, SoCalGas submitted AL 6014-G, which created the foundational principles for a Benefits Analysis Framework. Al 6014-G was approved by the CPUC on August 28, 2022. In D.23-04-042, issued April 28, 2023, the Commission found that the term “benefits analysis framework” should be now called the “uniform impacts framework,” further explaining that “research and development projects have an element of risk, which means that not all EPIC projects will directly benefit ratepayers in a quantifiable manner.” In support of these directives, SoCalGas RD&D proposes to make ongoing improvements to the UIAF, adapting as informed by the process and outcomes of proceeding R.19-10-005, participating in upcoming EPIC workshops, and continuing to work in consultation with Energy Division staff as directed in Res. G-3586.

5 New in 2023

5.1 Response to Stakeholder Input

Through ongoing conversations throughout the past year and an intensive outreach process conducted during the first quarter of 2022, RD&D staff identified many key issues important to stakeholders. These issues are summarized in:

- Appendix A: Stakeholder Input
- Appendix B: Public Workshop Questions & Comments
- Appendix C: Post-Workshop Stakeholder Input

Generally, RD&D staff confirmed that program areas, subprograms, and research areas were in alignment with how key stakeholders from relevant universities, national labs, research consortia, and businesses view the needs of the industry. When appropriate, SoCalGas RD&D incorporates input received into its research plans.

Figure 1: The SoCalGas RD&D Annual Outreach Program revealed numerous themes.

In 2022, several key themes emerged from stakeholder input. SoCalGas RD&D staff carefully reviewed this year's input (Appendices A, B, and C) and considered them against RD&D project selection criteria (Appendix D). Foremost among the identified themes were:

Outreach Takeaway	SoCalGas RD&D Strategy
Hydrogen is a key technology for decarbonization.	Across all of its program areas, SoCalGas RD&D is exploring the role of hydrogen in

A majority of outreach targets (Section 3.1) stressed the importance of exploring the role of hydrogen in the decarbonization of energy production, delivery, and end-use applications. From leveraging existing gas infrastructure and developing refueling options for heavy-duty trucks to exploring new ways to produce hydrogen that minimize water consumption, the consensus was that hydrogen is a key technology for decarbonization.	the decarbonization of energy. See Sections 7.3.3 (Areas 1, 3, 4), 8.5.3 (Areas 1, 3), 9.2.3 (Areas 1, 2, 3, 4), 9.3.3 (Area 1), 9.4.3 (Areas 1, 2), 9.5.3 (Areas 1, 2), 10.2.3 (Areas 1, 2), 11.3.3 (Area 2), 11.4.3 (Area 1), 11.5.3 (Area 2), and 11.6.3 (Area 1).
Support Carbon Capture, Utilization, and Storage (CCUS) projects. Many respondents indicated support for CCUS technologies—including direct air capture—and some stressed the need for developing commercial-scale projects to demonstrate that the technologies actually work.	SoCalGas RD&D supports CCUS projects through its Low Carbon Resources program. See Section 7.2.
Increase project equity. Some respondents recommended increasing the diversity of SoCalGas RD&D through greater engagement with student programs, locating projects in areas categorized as disadvantaged or low-income, and adding people from underrepresented groups to project teams.	Equity is a core and growing focus of SoCalGas RD&D. See Sections 4.3, 4.4, 7.2.5, 7.3.5, 8.2.1, 9.2.5, 9.3.5, 9.4.5, 10.2.5, 10.3.5, 11.2.5, 11.3.5, 11.4.5, 11.5.5, and 11.6.5.
Focus on improving the affordability of energy. Some respondents stressed the importance of pursuing technologies and projects that reduce energy costs for members of ESJ communities.	SoCalGas RD&D is keenly interested in improving the affordability of energy. Of the 379 projects it supported in 2021, 107 of them directly or indirectly would improve energy affordability. See Sections 7.3.4, 8.2, 9.2.4, 9.3.4, 9.5.4, 10.2.4, 10.3.4, 11.2.4, 11.3.4 11.4.4, 11.5.4, and 11.6.4.
Support development of RNG and low-carbon fuels RNG and other low-carbon fuels came up frequently in discussions with stakeholders.	SoCalGas RD&D explores and supports development of RNG and other low-carbon fuels. See Sections 7.2.3 (Areas 1, 2), 7.3.3 (Areas 2, 3, 5), 8.5.3 (Areas 1, 3), 9.2.3 (Area 3), 9.3.3 (Area 1), 9.5.3 (Area 1), 10.2.3 (Area 3), 10.3.3 (Area 2), 10.4.3 (Area 1), and 11.6.3 (Area 1).
Focus on system integrity. Stakeholders expressed interest in continuing research on how to support existing gas infrastructure through artificial intelligence (AI), data standards, and inspection technologies.	System integrity is a key focus of several RD&D research areas. See Sections 8.4.3 (Areas 1, 2), 8.5.3 (Areas 1, 2, 3), and 8.6.3 (Areas 1, 2, 3, 4).
Workforce development and education are vital to the energy transition. Numerous outreach respondents expressed a need for workforce development and training for students,	SoCalGas RD&D actively supports workforce development and education efforts in the projects it supports. In many cases, RD&D projects set the stage for future workforce development and

technicians, first responders, and engineers in hydrogen and other new technologies. Some also spoke of the importance of educating policy makers and legislators about the safety and reliability of natural gas, hydrogen, and RNG, as well as realistic timelines for the energy transition.	education activities. See Sections 4.3, 8.3.3 (Area 3), and 8.4.1.

5.2 Alignment with California's Decarbonization Goals

AB3232 requires California residential and commercial building stock to reduce their GHG emissions level by at least 40% below 1990 emissions levels (23.6 MMTCO2e) by 2030. According to a 2019 study by the Energy Future Initiative, even if the state enacted aggressive electrification policies and electrified 22% of residential buildings and all new construction by 2030, this would only equate to about 3.9 MMTCO2e in emissions reduction by 2030 or a 10% reduction from 2016 building emissions (39.4 MMTCO2e).

In comparison, energy efficiency has contributed to a decrease in the sector's emissions since 2000, despite the sector's growth since then. According to the California Energy Commission (CEC), mandatory energy efficiency codes and standards, plus programs that incentivize emissions reductions through behavioral and financial mechanisms, equates to a reduction of 8.4 MMTCO2e by 2030. Technology development that improves the energy efficiency of end-use gas appliances would only further drive emissions reduction potential. Therefore, a diversified pathway that includes improved energy efficiency, building retrofits, and fuel-switching (i.e., RNG, hydrogen, and electrification) will enable California to achieve its short- and long-term building decarbonization goal more cost-effectively and expeditiously.

While there is strong technical potential for each of these measures to play a role in reducing emissions, it is important to consider the impacts to buildings and homeowners involving costs, consumer preferences, and potential for disruption. It is critical to acknowledge that electricity and gas complement each other—both are needed and can reinforce each other. Taking a systemwide view of energy infrastructure that recognizes the value and coordinates the gas and electric systems to manage decarbonization affordability and resiliency provides the greatest overall benefits. One of the gas system's main strengths is its ability to meet extreme peaks. It can store, quickly ramp up, and deliver high volumes of energy on short notice and can handle large changes in volumes over time without operational, reliability, or financial strain. Without the inherent benefit of the gas system, the electricity system would be overburdened during the most crucial moments when our ratepayers need energy. For example, the electricity system currently struggles to meet peak summer loads. While these scenarios do not generally create a human life crisis, the complete removal of the gas system may create a winter seasonal peak demand for the electricity system. The gas system's seasonal peak is in the winter when heating load is the highest. Without the natural gas resiliency in the winter, a completely electrified energy infrastructure could pose a significant concern for heating loads resulting in loss of life. Therefore, a diversified energy system gives us the versatility to meet peak energy demand seasonally.

5.3 Coordination with CEC and Other IOUs

SoCalGas RD&D is committed to coordinating with the CEC; other government agencies including the California Air Resources Board (CARB), the South Coast Air Quality Management District (SCAQMD), and the U.S. Department of Energy (DOE), and other IOUs and municipal owned utilities.

One way that SoCalGas RD&D coordinates with others in the research community is through its annual public workshop. This year, the workshop was attended by representatives from the CEC and IOUs from across North America, including ATCO, ENGIE, Los Angeles Department of Water and Power (LADWP), National Grid, New Jersey Natural Gas, New York State Electric & Gas Corporation, NW Natural Gas Co., Pacific Gas & Electric Company (PG&E), and Peoples Gas (Section 3.2).

On January 31, 2022, SoCalGas submitted comments on the January 19, 2022, CEC Gas R&D Workshop. The comments addressed the CEC's research initiative to study hydrogen blending in power generation applications and included citations for the following SoCalGas RD&D projects:

- UCI Effect of Hydrogen Addition into Natural Gas on SCR of NOx Lab Testing
- UCI Fuel Flexible Microturbine Generator Development
- UCI Fuel Flexible Rotary Engine MicroCHP Development

In response, CEC staff commented that they will track these SoCalGas RD&D projects, since the results from these projects may inform future CEC solicitation development. CEC staff has subsequently contacted RD&D staff to discuss these projects in detail.

SoCalGas RD&D also engages and coordinates with other IOUs through involvement with national research consortia. These consortia are made up of IOUs and other researchers. Their intent is to leverage funding, expertise, and collaboration to maximize the value of research projects and avoid duplication of R&D efforts. In addition, the research consortiums meet with other organizations and agencies to discuss on-going and future research plans to avoid duplication[14], publish public Annual Reports[15] which summarize their work, and develop project proposals in response to agency funding opportunities. For example, CEC funding typically requires cost share to win an award. The OTD and UTD research consortiums monitor CEC solicitations as a mechanism to further leverage critical research dollars. Industry-led research consortiums such as UTD and OTD not only provide cost-share to projects, but also provide industry technical representation and input. See Section 6.2 for more detail about SoCalGas RD&D's participation in research consortia.

SoCalGas RD&D also works directly with other utilities to advance technologies that will benefit all Californians. SoCalGas RD&D recently collaborated with PG&E to support the

[14] For examples of research consortium affiliate organizations, please see: https://www.prci.org/About/PartnersAffiliates.aspx, https://www.utd-co.org/members/, and https://primis.phmsa.dot.gov/rd/workshops.htm.

[15] For examples of research consortium annual reports, please see: https://www.utd-co.org/wp-content/uploads/2021/12/UTD_Annual_Report_Research_Project_Summaries_2020-21.pdf, https://www.otd.org/wp-content/uploads/2021/10/OTD-Research-Project-Summaries-2020.pdf, https://www.nysearch.org/tech-brief-pdfs/2NYSearchBookUPDATEDFINALWEBFILE.pdf.

development of Brimstone Energy's low-cost, low-energy hydrogen and sulfuric acid co-production via electrolysis technology.[16] SoCalGas RD&D is currently working with LADWP and the DOE's Advanced Research Projects Agency-Energy to support a rapid temperature swing adsorption system for CO2 capture.[17]

SoCalGas RD&D regularly participates in CEC funding solicitations and is working with the CEC on a number of co-funded projects. In April 2022, the CEC announced proposed award funding for three hydrogen production technology projects supported by RD&D. The CEC is providing nearly $5 million to the awardees, with $1.9 million awarded to the University of Southern California for catalytic reformer development and $750,000 each to the University of California, Los Angeles and Susteon for hydrogen production technology development. To support these projects, SoCalGas RD&D committed a total of $700,000 to these projects. Also in April 2022, the CEC awarded GTI Energy and the University of California, Irvine $1.8 million to study the cost-performance-safety implications and emissions benefits of adopting up to 100% hydrogen to decarbonize large commercial buildings and industrial applications. SoCalGas committed a total of $700,000 with an additional $1 million in co-funding from PG&E, UTD, EPRI, and others to support this research.

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[16] Renewal: SoCalGas RD&D 2021 Annual Report, p. 81
[17] Id. p.74

6 Proposed 2023 Funding Allocations

6.1 Proposed 2023 Funding Allocations

The total authorized funding for the RD&D program was set by the 2019 General Rate Case (GRC) decision, which established the authorized funding for test year 2019 and the escalation and attrition rates for each subsequent year in SoCalGas' rate case cycle, including 2023. The total authorized funding for 2023 is $16,874,000.[18] Of that total, SoCalGas RD&D will allocate approximately 10% or $1,687,400 to program administration. Activities in the Program Administration Budget were organized to align with allowable EPIC administration cost categories developed in the process launched by D.21-11-028.

Program Administration Budget Items	2023 Forecast
Investment Plan Development	$170,000
Project Initiation	$104,008
Project Oversight and Governance	$26,002
Stakeholder Communication, Engagement, and Outreach	$430,000
Regulatory Support and Compliance	$450,952
Internal Management Coordination	$62,738
Program and Process Coordination and Improvement	$156,845
Administration Activities	$130,009
Supervision and Personnel	$125,476
Training and Development	$31,370
Total	**$1,687,400**

~~The remaining authorized budget, approximately $15,186,600, is allocated across the subprograms. First, each sub-program identified committed funds for 2023. These are finds that will be spent in 2023 with a high degree of certainty.~~

~~Next, each sub-program identified finds for projects that are under development for 2023. Sub-program personnel identified key research areas of interest for 2023. This funding is allocated to support projects in these key research areas for which some uncertainty in timing or budget remains. For example, on some projects, certain components such as research partner, testing location, co-funding source, or timeline have not yet been determined. The key research areas are examples of research concepts that could be funded if the appropriate project is developed. Funds may also be redirected to new research areas that arise during the plan year.~~

~~**Table 5:** RD&D Program Proposed 2023 Funding Allocations by Program and Subprogram.~~

~~**Programs**~~	~~**Program Funding**~~	~~**Subprograms**~~	~~**Subprogram Funding**~~
	~~$5,619,042~~	~~Renewable Gas Production~~	~~$2,809,521~~

[18] Any over- or under-spend from 2022 will be applied to 2023 in accordance with Resolution G-3573.

~~Low Carbon Resources~~		~~Carbon Capture, Utilization, & Sequestration~~	~~$2,809,521~~
~~Gas Operations~~	~~$3,644,784~~	~~Environmental & Safety~~	~~$728,957~~
		~~Operations Technology~~	~~$546,718~~
		~~System Design & Materials~~	~~$1,457,913~~
		~~System Inspection & Monitoring~~	~~$911,196~~
~~Clean Transportation~~	~~$2,126,124~~	~~Off-Road~~	~~$637,837~~
		~~Onboard Storage~~	~~$425,225~~
		~~On-Road~~	~~$637,837~~
		~~Refueling Stations~~	~~$425,225~~
~~Clean Generation~~	~~$1,670,526~~	~~Distributed Generation~~	~~$835,263~~
		~~Integration & Controls~~	~~$835,263~~
~~Customer End-Use Applications~~	~~$2,126,124~~	~~Advanced Innovation~~	~~$127,568~~
		~~Commercial Applications~~	~~$318,919~~
		~~Commercial Food Service~~	~~$148,829~~
		~~Industrial Process Heat~~	~~$850,450~~
		~~Residential Appliances~~	~~$680,359~~
~~Program Administration~~	~~$1,687,400~~		
~~**Total**~~	~~**$16,874,000**~~		

~~After careful review and consideration of stakeholder input (Appendix A), RD&D staff identified the subprograms listed above and the key research areas described below. In response to new stakeholder input, changing market conditions, new legislation or policy drivers, or significant advances in technology, RD&D Program staff may also choose to fund projects that are in alignment with overall program goals and objectives but do not fall under the research areas listed in the Research Plan.~~

Table 5 6: Revised RD&D Program Proposed 2023 Funding Allocations by Program and Subprogram.

Programs	Initial Program Funding	Subprograms	Initial Subprogram Funding	Incurred Costs [a]	Available for Reallocation	Reallocated Funds	Revised Subprogram Funding	Revised Program Funding
Low Carbon Resources	$5,619,042	Renewable Gas Production	$2,809,521	-	-	$1,122,084	$3,931,605	**$4,777,158**
		CCUS (Retired)	$2,809,521	($845,553)	$1,963,968	-	$845,553	
Gas Operations	$3,644,784	Environmental & Safety	$728,957	-	-	$250,000	$978,957	**$4,394,784**
		Operations Technology	$546,718	-	-	$250,000	$796,718	
		System Design & Materials	$1,457,913	-	-	$250,000	$1,707,913	
		System Inspection & Monitoring	$911,196	-	-	-	$911,196	
Clean Transportation	$2,126,124	Off-Road (Retired)	$637,837	($196,036)	$441,801	-	$196,036	**$1,134,579**
		Onboard Storage (Retired)	$425,225	$0	$425,225	-	$0	
		On-Road (Retired)	$637,837	($756,841)	($119,004)	-	$756,841	
		Refueling Stations (Retired)	$425,225	($181,702)	$243,523	-	$181,702	
Clean Generation	$1,670,526	Distributed Generation (Retired)	$835,263	$0	$513,929 [b]	-	$321,334	**$2,061,741**

		Integration & Controls	$835,263	-	-	$905,144	$1,740,407	
Customer End-Use Applications	$2,126,124	Advanced Innovation	$127,568	-	-	$100,059	$227,627	**$2,013,401**
		Commercial Applications	$318,919	-	-	$250,146	$569,065	
		Commercial Food Service	$148,829	-	-	$54,880	$203,709	
		Industrial Process Heat (Retired)	$850,450	$0	$257,222 [b]	-	$593,228	
		Residential Appliances (Retired)	$680,359	($419,772)	$260,587	-	$419,772	
Program Administration	$1,687,400	-	-	-	-	-	$1,687,400	**$1,687,400**
Comprehensive Gas RD&D database	-	-	-	-	($129,938) [c]	-	$129,938	**$129,938**
Comprehensive RD&D program evaluation	-	-	-	-	($675,000) [c]	-	$675,000	**$675,000**
Total			**$16,874,000**	($2,399,904)	$3,182,313	$3,182,313	$16,874,000	**$16,874,000**

[a] Includes actual and estimated incurred costs (Jan-Nov '23).
[b] Remaining funds for reallocation after discounting funds needed to complete in-progress projects as directed by Ordering Paragraph 8 of Res. G-3601.
[c] Funds directed to specific initiatives as directed by Ordering Paragraph 3.a of Res. G-3601.

Revisions pursuant to Res. G-3601:

Resolution G-3601 directed SoCalGas to modify its proposed RD&D funding allocation. To develop its revised proposal for 2023 funding allocation shown in Table 5, SoCalGas followed the guidance provided by the Resolution as discussed in this section.

Resolution G-3601 approved SoCalGas RD&D proposed allocation for the following subprograms as long as SoCalGas demonstrates the use of clean renewable hydrogen in its hydrogen related projects: (Res. G-3601, O.P. 3.a and O.P.3.b)

- Renewable Gas Production
- Environmental & Safety
- Operations Technology
- System Inspection & Monitoring
- Integrations & Controls
- Advanced Innovation
- Commercial Applications
- Commercial Food Service

In compliance with OP 3c, SoCalGas remains committed with the State's clean renewable hydrogen (CRH) vision and supports the overall direction the Commission is taking in G-3601 regarding the utilization of CRH in SoCalGas's research projects. SoCalGas understands that requiring CRH be used in hydrogen gas research and development approved by the Commission to be a novel requirement. Therefore, for active research projects that utilize hydrogen, SoCalGas will review the sources of gases used for each one to determine if the source complies with the definition of CRH. If it is concluded the hydrogen used does not fit the definition of CRH, SoCalGas will evaluate the feasibility of procuring CRH for the project at the volumes required. For projects where no options are feasible, next steps may include termination of contracts and reallocation of funds to an approved subprogram or suspension of contracts until an alternative solution is identified. As part of this evaluation, SoCalGas plans to share the findings, including market participants, quantities available to purchase, source and location of CRH, price, carbon intensity, purity, certification process, and estimated transportation costs, with Energy Division. These findings will help SoCalGas, the Energy Division, and research partners better understand the market for CRH, including the commercial arrangements needed to both procure CRH to comply with this requirement.

Res. G-3601 denied funding towards hydrogen blending projects in the System Design and Materials subprogram (Res. G-3601, O.P. 3.a). SoCalGas RD&D has three hydrogen blending projects under the System Design and Materials subprogram that are industry collaborative programs with many funders in which all project funds for these projects have been expended in 2023 prior to Res. G-3601 issuance as authorized by Res. G-3586 for multi-year projects and have completion dates in 2024. Therefore, no reallocation of funds is possible and rate-payer benefits, including benefits beyond the hydrogen blending scope are expected to be achieved at project completion. These projects are designated in Appendix E under "Hydrogen Blending Projects", column V.

Resolution G-3601 denied SoCalGas RD&D proposed allocation for the following subprograms: (Res. G-3601, O.P. 3.a)

- CCUS
- Off-Road
- Onboard Storage
- On-Road
- Refueling Stations
- Residential Appliances

Subprograms that were denied by the Commission are all being retired in the Revised 2023 RD&D Research Plan. A subprogram that is being retired has costs associated with retirement. The costs for retired subprograms are reflected in the revised RD&D funding allocation and include financial obligations incurred in 2023 up to Res. G-3601 issuance for activities related to multi-year agreements executed in 2022 or before, as authorized by Res. G-3586[19] . These obligations are divided into two categories: (1) Actual Incurred Costs, and (2) Estimated Incurred Costs. Additional information for costs associated with retired subprograms is shown in the revised Attachment B for each project. SoCalGas submits that this treatment is consistent with the precedent set by the Commission in the Senate Bill (SB) 1371 Bi-annual Leak Abatement proceeding. In that case, the Commission authorized recovery of costs SoCalGas recorded, in good faith and pursuant to preliminary guidance from Safety Enforcement Division (SED), while awaiting final resolution from the Commission.

Res. G-3601 allowed the continuation of in-progress projects and denied the proposed allocation for new projects in the Distributed Generation and Industrial Process Heat subprograms (Res. G-3601, O.P. 3.a and O.P. 7). SoCalGas appreciates the opportunity given by the Commission to continue the contracted projects under the Distributed Generation and Industrial Process subprograms. SoCalGas is retiring these two subprograms and is presenting in its revised 2023 RD&D Research Plan expenses for completing in-progress projects only. The list of in-progress projects has been updated to reflect agreements executed in 2022, Including the ones contracted between the submission of SoCalGas AL 5991-G and the end of the 2022.

Res. G-3601 also directed SoCalGas to reallocate funding allocations from denied subprograms into activities -, such as a comprehensive RD&D program evaluation and a comprehensive Gas RD&D database. It also directed SoCalGas to consider reallocate funds towards research involving pipeline and system integrity, gas decommissioning, and cybersecurity. (Res. G-3601, O.P. 3.a)

In its revised 2023 RD&D funding allocation, SoCalGas is reallocating funds from denied subprograms towards a comprehensive RD&D program evaluation ($675,000) and a comprehensive Gas RD&D database ($129,938), as directed by Res. G-3601.

SoCalGas RD&D is committed to developing and proposing new RD&D projects and reallocating funds towards initiatives that directly benefit gas ratepayers, including those research areas approved by Res. G-3601. Accordingly, we will continue to pursue new and innovative research areas, including those mentioned in the Resolution such as gas system decommissioning, system integrity and cybersecurity. Care will be taken to make sure research undertaken in these areas will add to ongoing research and policymaking activities. For instance, new RD&D projects in the Gas Decommissioning research area

[19] Res. G-3586 at page 7.

will draw guidance from the Long-term Gas System Planning OIR (R.20-01-007),[20] as well as attempt to build off other relevant research, such as that funded by the CEC under PIR-20-008, September 2023.

In response to the Resolution, SoCalGas is proposing an initial provisional funding allocation to these new areas to support research that may be practical to accomplish in this funding cycle. A more comprehensive review of research needs will be performed to further develop these subprograms and inform appropriate scope and budget for each initiative in the future. In its revised 2023 RD&D Research Plan SoCalGas is increasing the allocation of funds towards the System Design & Materials subprogram by $250,000 to increase the number or scope of projects in the pipeline and system integrity area. The Environmental and Safety subprogram allocation proposal was increased by $250,000 to budget for projects associated with gas system decommissioning. The Operations Technology subprogram funding allocation was also increased by $250,000 to budget for cybersecurity research projects. The Integration and Controls subprogram also received an additional $250,000 in reallocated funds to further develop cybersecurity related research projects.

6.2 Funding Allocations by Research Consortium

Per Resolution G-3586, SoCalGas RD&D is instructed to:

> *Provide detail quantifying research funding allocations by research consortium, as well as project costs related to each consortium.*

The breakdown for each Research Consortium dues is listed in the table below. Consortium dues in total represent approximately 10% of total combined project costs.

Research Consortium	2023 Dues~~[21]~~		
	Total	**Portion for Administration**	**Portion ~~available for Project~~ Allocat~~ion~~ed to RD&D Projects**~~[22]~~
NYSEARCH	$72,250[(a)]	$72,250	$0
OTD	$750,000[(b)]	$60,000	$690,000
PRCI	$150,000[(c)]	$50,000	$100,000
UTD	$350,000[(d)]	$35,000	$315,000

[(a)] NYSEARCH dues estimate based upon dues history. Membership comprises 25 regulated gas utilities[23]

[(b)] OTD dues estimate: The dues total is based upon the SoCalGas number of meters with the maximum dues amount of $750,000. OTD dues are offset by projects funded under the SB1371 Leakage Abatement program. Membership comprises 29 natural gas distribution companies[24].

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[20] See R.20-01-07 February 22, 2024 Assigned Commissioner's Ruling Scheduling Phase 3 Prehearing Conference and Providing Joint Agency Staff Gas Transition White Paper and Draft Phase 3 Scope and Schedule for Party Comment, Attachment A.

~~[21] Estimated dues. OTD dues offset by projects funded under the SB1371 Leakage Abatement Program. PRCI dues are calculated annually based upon miles of pipe.~~

~~[22] Estimated based upon historical trends after administrative deduction.~~

[23] https://www.nysearch.org/about.php#membership

[24] https://www.otd.org/

[(c)] PRCI dues estimate: PRCI dues are calculated annually based upon miles of pipe as reported to DOT the preceding year. PRCI membership includes 60 companies who are operating natural gas transmission and crude oil and petroleum products pipelines and other organizations and service providers supporting the industry[25].
[(d)] UTD dues estimate: The dues are based upon the SoCalGas number of meters with the maximum dues amount of $350,000. UTD membership composed of 20 natural gas distribution companies[26]. Note: SoCalGas RD&D will not fund membership in UTD. after 2023.

The total consortium-related project costs in the table below include 2023 "continuing projects" (projects previously initiated and spanning multiple years) based upon estimated end dates as of December 31, 2022.[27] The leverage ratio shows the research value proposition for every dollar SoCalGas funds. For example, a leverage ratio of 32.67x for $1.5m of funding gives $50.5m worth of research. More details on continuing projects can be found in Appendix E - Project Details.

Research Consortium	~~Total Consortium-related Project Costs~~[28] RD&D Project Funding by Consortium		
	Total SoCalGas Funding~~Cost~~	Total Project Funding~~Cost~~	Total Leverage Ratio - Project
NYSEARCH	$753,397 ~~528,001~~	$9,872,862 ~~3,465,111~~	13.1x
OTD	$2,587,968 ~~527,050~~	$24,689,727 ~~8,320,833~~	9.6x
PRCI	$1,781,309 ~~475,028~~	$32,351,524 ~~18,046,046~~	18.2x
UTD	$915,022 ~~12,711~~	$12,781,327 ~~578,000~~	14x ~~45.47x~~
All Consortiums	$6,037,696	$79,695,440	13.2x

SoCalGas RD&D has identified six ratepayer benefits to align with subprograms and their projects: safety, reliability, operational efficiency, improved affordability, reduced GHG emissions, and improved local air quality.[29] These benefits are reviewed along with other criteria when SoCalGas selects consortium projects to fund.[30] The following illustrative pie charts show generally the distribution of projects delivering each benefit, by consortium.

[25] https://www.prci.org/Membership/2928.aspx
[26] https://www.utd-co.org/wp-content/uploads/2021/09/UTD-Prospectus-Sept2021.pdf
[27] Advice Letter 5991 Total project cost was based upon 2023 continuing projects as of 5/1/2022.
~~[28] The total consortium-related project costs include 2023 "continuing projects" (projects previously initiated and spanning multiple years) based upon estimated end dates as of 5/1/2022. More details on continuing projects can be found in the Project Details section of this document Appendix E. The project selection and finding process for 2023 year will begin 4th quarter 2022.~~
[29] 2022 SCG RD&D Annual Report, page 8: Project Benefits
[30] Appendix D: Project Selection Process

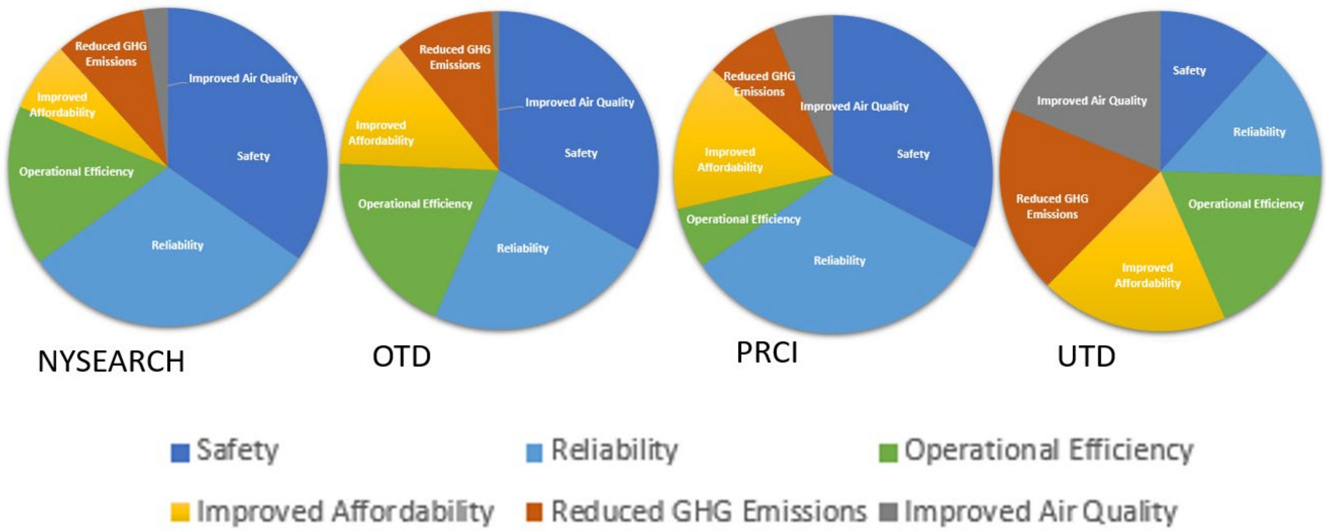

Figure 1-1: Percentages of projects delivering each ratepayer benefit by consortium

The utilization of consortium dues varies by organization. Dues cover administrative expenses, with the remaining portion allocated directly to SoCalGas-initiated or selected ~~to~~ projects.

As demonstrated by the tables above, the majority of consortium spend and membership dues are allocated to R&D projects that are either initiated by or specifically selected for funding by SoCalGas. The subcategory of funds only allocated to administrative expenses are justified by direct ratepayer benefits by many aspects of the programs. Participation in the research consortiums facilitates collaboration and knowledge sharing between SMEs from other natural gas system operators and industry RD&D program and project managers. Research consortiums generally provide members the opportunity to learn about and discuss emerging operational and utilization issues and needs within the industry, both nationally and internationally.

The ratepayer value of such collaboration includes:

1. Provide subject matter experts a forum for learning and gaining operational insights regarding differences in pipeline system materials and equipment, operating environments, operational experiences, procedures, and practices;
2. Operational knowledge that may only apply to a small subset of system assets or operational conditions;
3. Knowledge sharing of pipeline incidents, causes or insights on interactive threats with very low probability of occurrence but high consequence;
4. Knowledge sharing between large and small system operators that can provide a positive effect on the performance of the overall natural gas supply chain,
5. Knowledge of emerging areas of research or technologies that could be utilized by SoCalGas to support operational efficiency, pipeline safety, system reliability, and environmental improvement.

Consortium membership leverage administration expenses related to the bidding process and management of large National and State research projects funded by the DOE, PHMSA and CEC. Membership also leverages existing relationships with federal and state regulators, industry, national laboratories, and academic institutions, which also can be related to the leverage of administrative costs of the program. For regulated utilities, it is challenging to develop in-house expertise in technology transfer as it is a lengthy, complicated process. In addition, consortiums use specialized resources that are dedicated to RD&D assignments that typically span many years of development. Managing intellectual property (IP) and licensing is a specific skill set that is typically more cost-effectively managed by consortiums, since RD&D is typically performed by innovators and/or companies who do not have the necessary industry expertise and specialty resources.

Consortium membership also provides SMEs and company employees with access to literature repositories to research relevant information that would otherwise either not be available or need to be purchased regardless if SoCalGas funded the research. Examples of the benefits of this information include: provides centralized banks of information for literature review; access to knowledge that could pertain to new regulations on the horizon or supporting new company initiatives; ability to leverage previous work to support implementation of large-scale projects, or to address potential safety and integrity issues identified by other utilities. For example, when PHMSA issued the Notice of Proposed Rule Making in 2016 for the Mega Rule pertaining to the safety of onshore gas transmission pipelines, SoCalGas used the consortium historical research to determine where further research was needed to meet the forthcoming requirements supporting operations and integrity management.

The RD&D projects funded within each consortium stand on their own merits regarding ratepayer benefits; however, following is a list of additional potential ratepayer benefits:

1. For a technology or tool to evolve and advance within Technology Readiness Levels (TRL)[31] it must withstand various operational challenges and impacts that cannot show themselves until later stages of product development or in early customer adoption trials. With R&D consortiums more companies are involved in piloting the technology or service in pre-commercial demonstrations or testing in a wider range of commercial and operational conditions than individual operators can typically achieve.
2. R&D Consortiums are better positioned to identify and develop potential commercial partners who must be convinced to take the business risk and accept innovations developed from consortium projects by providing prospective manufacturers or service providers more market potential because of the larger number of customers that it represents throughout the country, continent or globally.
3. R&D consortiums can provide commercial partners with insight into broader industry needs to set market expectations and input on metrics for success.
4. R&D consortiums can provide more expedient commercialization and implementation of technologies available for the natural gas industry.
5. R&D consortiums have experience and visibility with government agencies especially with their research funding opportunities and solicitations.

[31] TRL is a metric used for describing technology maturity. More information at https://www.directives.doe.gov/terms_definitions/technology-readiness-level

Endorsement by federal agencies for funding research to support proposed regulatory requirements or regional considerations. Successful technology transfer often comes from external drivers such as commercialization incentives, state-level regulatory drivers or other means for encouraging 'early adopters' of new technology.

6. R&D consortiums typically have dedicated technical managers working on behalf of multiple industry customers with consensus-based specifications that are tested against commercial requirements.

The following are some examples of successful research performed by research consortiums that SoCalGas funded.

NYSEARCH – In-Line Inspection Technologies RD&D

The Explorer series of robotics inspection platforms is a wide range of technologies developed by the NYSEARCH consortium to address issues related to pipeline integrity, specifically the inspection of non-piggable pipe. The research started in 2003 with SoCalGas joining as a funder in 2004. The Explorer became commercially available with corrosion detection and mechanical damage sensing capabilities in 2011 when SoCalGas demonstrated the Explorer 10/14 MFL platform. NYSEARCH and its members then initiated subsequent development to add sensing and operational capabilities to increase Explorer's efficacy, effectiveness and productivity. Recently completed research worked to expand the crack sensing capabilities. This project was featured in an RD&D webinar mid-2023.[32] Other efforts are underway to extend the inspection range, reducing the number of launch points necessary to perform an inspection.[33] SoCalGas ratepayers benefit by the technology, prioritized by project funders, reaching commercialization more quickly. The SoCalGas Integrity Management Program utilizes the existing robotic inspection platform, and has identified a list of improvements to meet future needs including improved crack detection sensitivity for tighter cracks, and the ability to handle the presence of liquids and debris to reduce the need to stop inspections to clean the line.

OTD - Cross-bore Technologies RD&D

In 2010 a house explosion occurred in St. Paul, Minnesota. The cause was determined to be an incident where a gas line was directionally drilled through a sewer line, commonly referred to as a "cross-bore". This event prompted new research to develop tools and methodologies to inspect for, detect, mitigate, and prevent cross-bores to address this potentially high-consequence threat. SoCalGas joined with other utilities in the Operations Technology Development consortium to fund research which resulted in detection tools and best practices. This work formed the foundation of the current SoCalGas "Sewer Lateral Inspection Program" that works to find and mitigate existing cross-bores and prevent future incidents from occurring. Research was also performed to develop technology to detect obstacles in advance of horizontal directional drilling (HDD) operations. This is an example, where SoCalGas and its ratepayers benefited from the experiences of other utilities and participation in a R&D consortium. SoCalGas is

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[32] Explore Robot – Seam Weld Crack Sensor (M2016-004 Ph IV) https://youtu.be/qcJSjGZ3xrY
[33] Extending Energy Harvesting to Other Explorer Sizes - A Feasibility Study (M2021-011), Explorer Wireless Range Extender (M2021-006)

currently funding research to advance the HDD forward sensing capabilities[34] and to determine the parameters where high-pressure water jets damage plastic pipe[35]. SoCalGas anticipates incorporating the project results into existing programs and outreach materials for contractors making them aware of these potential hazards.

PRCI – System Design & Materials Research

In response to safety advisories from Pipeline and Hazardous Material Safety Administration and the Canada Energy Regulator, Pipeline Research Council International (PRCI) started research to find a solution to prevent girth weld failures of newly constructed pipelines in-service or during construction hydrostatic leak testing[36]. The essential goal was to prevent similar girth weld incidents from happening in both in-service pipelines and pipelines to be built in the future. Historically, girth weld failures have been a very small portion of pipeline incidents. However, at least 30 incidents have occurred world-wide indicating that this is not a one-of-a-kind event. The PRCI project reviewed available incident information determining that weld strength undermatching, heat-affected zone softening, and elevated loads were the main factors in causing the girth weld failures. The project deliverables included recommendations and guidance to improve industry practice and support potential updates to standards and design specifications. This project is an example where SoCalGas collaborated with industry experts to develop technical solutions to prevent incidents that could impact safety and system reliability for SoCalGas ratepayers.

UTD – High Efficiency Smart Convection Oven

The objective of this project is to develop a prototype high-efficiency smart convection oven that increases efficiency by at least 5% and integrates smart operating controls to maximize food preparation quality and consistency. Previously, researchers investigated a high-efficiency oven design, showing that this configuration in bench-scale tests achieved a 3% improvement in cooking efficiency and a 10% improvement to preheat energy use despite needing to be fully optimized. Based on these results and improvement areas in the initial design, the project team anticipates a 5%-10% increase in cooking efficiency should be achievable once they optimize the system. In addition, the team expects a targeted 10%-20% reduction in NOx and carbon monoxide emissions. In this project, researchers are incorporating a heat exchanger to recover heat from the flue and feed it back into the combustion air. In 2021, the project team completed basic testing on the modified heat exchanger. Researchers specified and ordered a new prototype burner with a premix system. The project team installed the new burner in the oven and completed some initial testing. The group modified the oven to mount the new burner instead of the existing burner. In 2022, additional testing and modification were underway. Discussions with a leading manufacturer continue regarding commercialization opportunities and other next steps to make this more efficient oven available to end users.

[34] ORFEUS Obstacle Detection Technology for Horizontal Directional Drilling (5.16.k.2)
[35] Plastic Gas Pipe Damage Assessment due to high pressure water jets and cross bores (5.23.g)
[36] https://www.prci.org/Research/DesignMaterialsConstruction/DMCProjects/MATH-5-3B/101449/249051.aspx

7 LOW CARBON RESOURCES

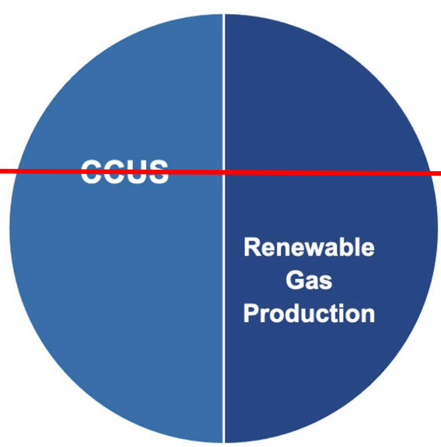
The primary goal of the Low Carbon Resources program area is to decarbonize the gas supply while maintaining its affordability and reliability. To achieve this goal, program staff members develop, promote, and advance new technologies aimed at increasing and expanding the production and use of hydrogen and renewable natural gas (RNG), displacing conventionally sourced pipeline gas, and capturing and permanently removing atmospheric GHG emissions. RD&D Program personnel in the Low Carbon Resources program area focus their efforts on the following goals:

- Increasing the availability of renewable gas and promoting pipeline decarbonization solutions by advancing production technologies that diversify renewable gas feedstocks and pathways.
- Offsetting emissions from conventional natural gas use by capturing and permanently removing atmospheric GHG emissions through carbon capture utilization and sequestration (CCUS) technologies.

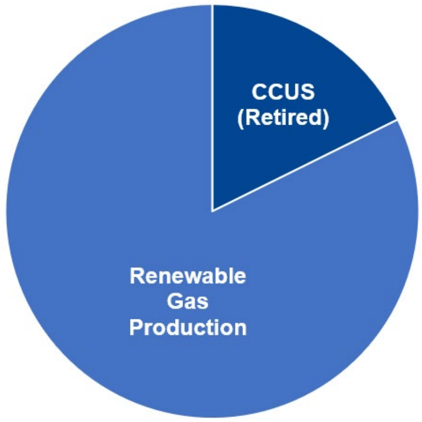
7.1 Proposed 2023 Low Carbon Resources Funding Allocation

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the CCUS subprogram in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for CCUS includes SoCalGas' existing contractual obligations prior to the issuance of Res. G-3601.



Subprogram	Allocation
~~CCUS~~	~~50%~~
Renewable Gas Production	50%
Total	$5,619,042



Subprogram	Original Allocation	Revised Allocation
CCUS (Retired)	50%	18%
Renewable Gas Production	50%	82%
Total	**$5,619,042**	**$4,777,158**

Figure 2: Summary of proposed 2023 Funding Allocations for Subprograms within the Low Carbon Resources Program.

7.2 Carbon Capture, Utilization, and Sequestration (Retired)

7.2.1 Subprogram Overview

This subprogram focuses on carbon capture, utilization, and sequestration—all vital in the fight against climate change. Roughly half of the excess CO_2 released into the atmosphere by human activity is absorbed by plants and the world's oceans. CCUS technologies seek to capture, utilize, or sequester the balance of these CO_2 emissions through a variety of approaches, including direct air capture coupled with either conversion into plastics, cement, and biofuels (carbon capture utilization or CCU) or sequestration into depleted oil fields and saline aquifers (carbon capture sequestration or CCS). This subprogram's portfolio also includes methane pyrolysis projects in which solid carbon is produced from a methane feedstock and captured simultaneously with hydrogen generation. However, because the carbon produced can either be converted into a useful product or sequestered in solid form, methane pyrolysis will be listed as a stand-alone category under CCUS.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the CCUS subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 7.2.6.

7.2.2 Policy Considerations

Carbon capture can help California reach its ambitious decarbonization and climate change mitigation goals more expeditiously by not only offsetting emissions from various GHG-emitting sectors, but also by creating a circular and carbon-negative economy. This subprogram can impact public policy by providing a realistic pathway for California to reach its carbon neutrality goals by 2045. The report *Getting to Neutral*, published by the Lawrence Livermore National Laboratory, indicates that California needs to remove 125 metric tons of CO_2 per year by 2045 to achieve state carbon neutrality goals. In addition, simultaneous carbon capture and hydrogen production pathways, such as biomass gasification with CCUS or methane pyrolysis, can make large-scale carbon removal solutions cost-effective in California. CCUS can support various California policies and regulations.

Policy	Description
AB 3232	Building decarbonization
EO B-55-18	2045 Carbon-neutral California economy
Clean Air Act	Air quality standards for NOx and PM
LCFS	Reduce carbon intensity of transportation fuels
AB 8	Development of 100 hydrogen refueling in California
EO B48-18	200 hydrogen refueling stations in California by 2025

7.2.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Carbon Capture**
  Carbon capture explores different carbon capture pathways, techniques, and methodologies. Carbon capture technologies under consideration in this area aim to investigate and improve various CO_2 extraction and capture technologies while meeting cost and efficiency constraints needed for mass deployment. For example, CO_2 could be captured from biogenic point sources to enhance RNG yield and recovery from biodigesters, from industrial point sources to prevent release of CO_2-laden flue gas to the atmosphere, from atmospheric sources via direct air capture, and from oceanic carbon sources via CO_2 bipolar membrane electrodialyzers. All these technologies are at different stages of development and could revolutionize SoCalGas' ability to offset carbon emissions post-release.
- **Area 2: Carbon Utilization and Sequestration**
  Carbon utilization encompasses a wide variety of conversion technologies through which CO_2 is converted into valuable chemicals, including methanol, plastics, dimethyl ether (DME), concrete, and biofuels such as RNG. Several technologies and processes can be leveraged to convert CO_2 into useful products, including:
  - Electrochemical and electrocatalytic processes, such as, plastics and biofuels production from CO_2 and water using electricity
  - Electro-methanogenesis, that is, RNG production from CO_2 and water using electricity
  - Mineralization processes, such as concrete production

  Alternatively, CCS involves the use of geological formations, such as active or depleted oil and gas reservoirs, as well as saline aquifers in the San Joaquin Valley to sequester CO_2. Studies by the Intergovernmental Panel on Climate Change (IPCC)[37] and the California Council on Science and Technology (CCST) have shown that CCS has the potential to reduce carbon emissions by billions of metric tons and may be an integral part of meeting California's climate goals in 2050.[38] Indeed, CCS allows for existing fossil fuel resources, such as natural gas, to be

[37] IPCC, 2014, Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, page 151.
[38] CCST, 2011, California's Energy Future: The View to 2050.

used in a way that produces far fewer carbon emissions than their use without CCS. Due to the potential importance of CCS in meeting California's long-term climate goals, CARB plans to integrate CCS into its climate programs in compliance with the AB 32 requirements that GHG emissions reductions achieved are real, permanent, quantifiable, verifiable, and enforceable. Studies have concluded that there is sufficient pore space available in California to inject tens of billions of metric tons of CO_2. CCS is already being deployed to sequester carbon emission from large-scale steam methane reforming (SMR) facilities and improve the carbon intensity of natural-gas-derived hydrogen. Projects in this research area aim at identifying and demonstrating the most economically viable CCS pathways, including co-generation of hydrogen and electricity. In addition, synergies can also exist between CCS technologies and various renewable gas production pathways, such as biomass gasification.

- **Area 3**: **Emissions-Free Hydrogen Production via Methane Pyrolysis**
  SoCalGas is investigating multiple methane pyrolysis pathways. Methane pyrolysis is a nascent but extremely interesting technology that consists of bubbling methane into a molten solution to decompose it into hydrogen and solid elemental carbon. The carbon can be used for a wide variety of applications, such as cement additives and carbon nanotubes. This technology has tremendous decarbonization potential because it does not generate any carbon emissions and can therefore reduce the cost of large-scale hydrogen generation while simultaneously offsetting carbon emissions.

7.2.4 Subprogram Benefits

Benefit	Explanation
Reliability	Leveraging synergies between renewable energy surplus/curtailment, carbon capture, and RNG production from captured CO_2 through advanced methanation processes can help improve gas system reliability and reduce reliance on out-of-state gas resources while simultaneously decarbonizing the pipeline. This benefit relates to the identical benefit under the "Renewable Gas Production" subprogram.
Environmental: Reduced GHG Emissions	CCUS systems can permanently remove CO_2 from the air, resulting in potentially negative overall carbon emissions. In addition, emissions-free hydrogen production via methane pyrolysis can further help decarbonize the pipeline and reduce its associated GHG emissions as well as offset emissions from hard-to-decarbonize industrial sectors.
Environmental: Improved Air Quality	Hydrogen produced from methane pyrolysis can improve air quality.

7.2.5 Equity Considerations

CPUC ESJ ACTION PLAN GOAL 2

Increases investment in clean energy resources to benefit ESJ communities, especially to

Deployment of carbon capture technologies near industrial facilities, most of which are co-located in ESJ communities, can improve the air quality in those communities. In addition, hydrogen from methane pyrolysis can be used directly to provide emissions-free energy in hard-to-decarbonize industries, such as steel and aluminum, which are also located in ESJ communities. These benefits to ESJ communities are in line with Goal 2 of the CPUC ESJ Action Plan. Equally as important, by offsetting GHG emissions, CCS technologies will reduce the negative impact of climate change on ESJ communities (Section 4.1).

improve local air quality and public health.

7.2.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Low Carbon Resources Program Carbon Capture, Utilization & Sequestration Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$615,000	-
Actual Incurred Cost Jan-Nov 2023	-	$ 816,567
Funds for Project Under Development for 2023	$2,194,521	$0
Estimated Incurred Cost Jan-Nov 2023[a]	-	$28,987
Total Sub-program Funding for 2023	$2,809,521	$845,553
Funds Available for Reallocation	-	$1,963,968
Sub-program Percentage of Funding	50%	18%

[a] Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

7.3 Renewable Gas Production

7.3.1 Subprogram Overview

This subprogram focuses on the safe, reliable, and cost-effective production of renewable gaseous fuels—specifically RNG and hydrogen—from various feedstocks and multiple technological pathways.

7.3.2 Policy Considerations

Renewable gas production aligns and conforms with California's decarbonization goals through its direct relevance and applicability to several key policies. By reducing the carbon intensity of the gas grid through its gradual decarbonization, this subprogram supports the following policies:

Policy	Description
AB 3232	Building decarbonization
EO B-55-18	2045 Carbon-neutral California economy
Clean Air Act	Air quality standards for NOx and PM
SB 32	Regulating and monitoring GHG emission sources
AB 32	GHG emission reduction targets

SB 1383	Methane (CH_4) emissions from organic waste
LCFS	Reduce carbon intensity of transportation fuels
AB 8	Development of 100 hydrogen refueling stations in California
EO B48-18	200 hydrogen refueling stations in California by 2025

7.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Renewable Hydrogen Production via Advanced Water-Splitting**
  Direct, high-efficiency sunlight/photon-driven water splitting into hydrogen and oxygen is an important research area with tremendous potential to streamline the conventional, multi-step water electrolysis process by coupling renewable electric power and water electrolysis into a one-step hydrogen-producing process. By decoupling green hydrogen production from the power grid, this technology would also eliminate intrinsic power system conversion and transmission losses, costly transmission system upgrades, and competition with electricity end users. In addition, the Low Carbon Resources Program area is also exploring ways to reduce conventional electrolysis cost and improve its efficiency by relying on earth-abundant catalysts and exploring pathways to reduce the operating cost burden imposed through electric T&D costs.
- **Area 2: Renewable Methane Production via Various Methanation Pathways**
  Renewable methane production from biogenic CO_2 with methanation—via conventional thermo-catalytic methanation, electrocatalytic processes, or the use of biological methanogens—is a key area of research that can be broadly deployed to capture and convert biogenic CO_2 emissions from bio-digesters, ethanol plants, landfills, and biomass gasifiers into RNG. Therefore, methanation technologies can expand the availability of renewable gas and avoid the upstream production, gathering, storage, transportation, and end-use GHG emissions associated with fossil-sourced gas; reduce net emissions; and improve air quality. Moreover, RNG produced via methanation has approximately triple the energy density of hydrogen (approximately 990 British thermal units per standard cubic foot [Btu/scf] versus 330 Btu/scf) and, most importantly, can be directly injected into the existing gas grid without the need for any system retrofit or modification.
- **Area 3: Renewable Gas Production via Biomass Gasification**
  Biomass is an abundant domestic resource that literally “recycles” CO_2. California has tremendous biomass resources that can be leveraged to not only produce renewable energy, but also mitigate the effects of devastating fires, which release very large quantities of GHG and criteria pollutants. Biomass gasification uses a controlled process involving heat, steam, and oxygen to convert biomass to hydrogen, RNG, and other products without combustion. Because growing biomass removes CO_2 from the atmosphere, the net carbon emissions of this method can be low, or even negative, especially if coupled with CCUS in the long term. Key challenges to hydrogen production via biomass gasification involve reducing costs associated with capital equipment and procuring continuous biomass feedstocks.
- **Area 4: Distributed Hydrogen Production via Advanced Steam Methane Reforming of Biomethane**

SoCalGas is exploring different SMR technologies, including advanced catalytic non-thermal plasma (CNTP) and 3-D printed meso- and micro-channel SMR reactors. SMR technology has progressed greatly in recent years with the development and manufacturing of a new, high-efficiency, low-cost, modular, combustion-free, solar- and/or induction-heat-driven, SMR technology for distributed hydrogen production. Originally developed by PNNL and being commercialized by STARS corporation, this technology has now reached a high technology readiness level (TRL) and is being deployed for field demonstration to support distributed hydrogen production. Incidentally, the first-ever production of oxygen on Mars was recently achieved by MOXIE (Mars Oxygen In-situ utilization Experiment) onboard the NASA Mars2020 using similar 3-D printed microchannel heat exchanger technology, originally developed by PNNL, and now used in the STARS SMR reactor, which is licensed to SoCalGas.

- **Area 5: Concentrated Solar Power Technology for Renewable Gas Production**
  Concentrated solar power (CSP) technology can be leveraged to drive renewable gas production through seamless integration with biomass conversion processes to further reduce the carbon intensity of biomass-derived renewable gas, increase system efficiencies, and improve overall performance.

7.3.4 Subprogram Benefits

Benefit	Explanation
Reliability	Broadly, the gas grid can improve energy reliability by absorbing curtailed power and synchronizing renewable energy supply with demand by storing energy in the form of RNG/hydrogen and shifting utilization across days, weeks, and months. Specifically, surplus renewable energy from wind, solar, and organic wastes can be channeled to make hydrogen for pipeline injection and long-duration energy storage. Alternatively, renewable hydrogen can be processed with biogenic CO_2 emissions to produce RNG via methanation processes. In 2020, up to 1,586,500 megawatt hours of electricity were curtailed in California according to the California Independent System Operator. This translates to approximately 32,000 metric tons of hydrogen production from electrolysis and, correspondingly, 168,000 metric tons of CO_2 that potentially could have been recycled to methane from methanation pathways. In addition, hydrogen and RNG can be produced from biomass—a clean, reliable, locally available energy resource.
Safety	The latest hydrogen high-pressure tube trailer storage technology can allow the transport of 560–720 kilograms for on-road vehicles. Distributed hydrogen generation of similar capacity located at end-user sites and closely matching production to end-user demand eliminates the need for hydrogen transportation from centralized production points in high-pressure containers and large quantities of end-user storage, making hydrogen adoption inherently safer. In addition, small, modular on-

	site hydrogen generation systems contain relatively small amounts of hydrogen and can more easily be turned off should a plant upset occur.
Improved Affordability	The development of technologies and innovations for renewable gas production at the lowest possible cost would result in increased affordability and accessibility of renewable gas to ratepayers. Critically, a hydrogen production target price of $2 per kilogram by 2030 would allow hydrogen to become a cost-effective consumer alternative to conventional fuels.
Environmental: Reduced GHG Emissions	Hydrogen and RNG production can displace fossil-sourced hydrocarbons, thereby reducing, mitigating, or eliminating associated CO_2 and methane emissions. Carbon-negative hydrogen production cycles are now being deployed that directly remove CO_2 from the atmosphere.
Environmental: Improved Air Quality	Replacement of fossil-sourced gas with renewable hydrogen can improve air quality, especially in industrial zones, by facilitating the transition from conventional combustion technologies to electro- and thermo-catalytic processes that eliminate NO_x and PM emissions.

7.3.5 Equity Considerations

By decarbonizing the pipeline and replacing its fossil-sourced content with renewable gas, this subprogram seeks to reduce emissions and improve air quality in areas neighboring industrial facilities, most of which fall within ESJ Communities. This work is in direct alignment with Goal 2 of CPUC's ESJ Action Plan: "Increase investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health." Equally as important, by reducing GHG emissions, the development and deployment of zero-emission transportation fuels will reduce the negative impact of climate change on ESJ communities (Section 4.1).

7.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Low Carbon Resources Program Renewable Gas Production Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$0	-
Actual Incurred Cost Jan-Nov 2023	-	$862,535
Funds for Project Under Development for 2023	$2,809,521	$1,946,986
Reallocated Funds from Available Funding	-	$1,122,084
Total Sub-program Funding for 2023	$2,809,521	$3,931,605
Sub-program Percentage of Funding	50%	82%

SoCalGas is proposing to reallocate a portion of the available funds to the Renewable Gas Production subprogram, in part, to enable new and existing projects to meet the requirements for utilization of clean renewable hydrogen. This will also provide additional ratepayer benefits as utilization of clean renewable hydrogen will result in reduced GHG emissions and improved air quality. Funding additional projects in the Renewable Gas Production subprogram will help accelerate development and de-risk clean energy technologies, such as water electrolysis for hydrogen production. These projects can provide ratepayer benefits by helping to reduce costs and improve affordability of clean renewable fuels.

As clean technologies in the Renewable Gas Production subprogram advance via demonstration projects, additional funds will be needed to accommodate increased research costs that will arise from developing these demonstrations. These additional costs include the necessary construction costs to adapt host sites to the requirements of the technology demonstration project. Moreover, SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline, allowing these additional funds to be prudently and expeditiously deployed towards projects that can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

8 GAS OPERATIONS

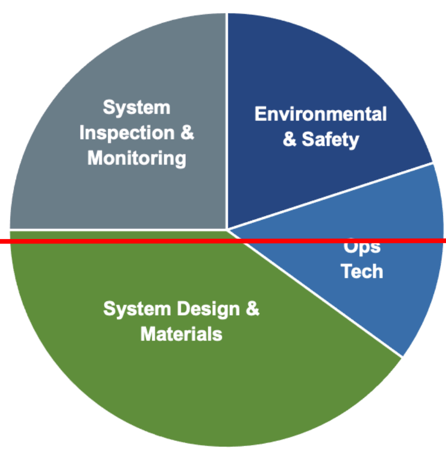
The Gas Operations Program area supports pipeline and storage operations through innovations that enhance public and employee safety, maintain system reliability, increase operational efficiency, and minimize GHG and operational impacts to the environment. The program also facilitates technology development driven by emerging regulatory requirements. Its primary goal is to develop, test, and introduce new gas operations technologies that are beneficial to ratepayers, public safety, and the environment.

More broadly, the objectives of the Gas Operations Program area are to:

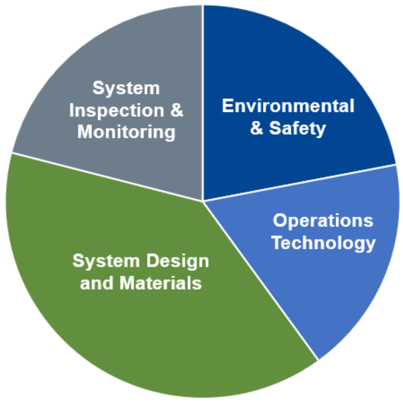
- Improve gas safety and system integrity
- Improve or enhance system reliability
- Advance system design and materials
- Increase operational efficiencies and effectiveness
- Reduce system emissions

The program invests in technology development projects in the following subprograms: 1) Environmental & Safety, 2) Operations Technology, 3) System Design & Materials, and 4) System Inspection & Monitoring.

8.1 Proposed 2023 Gas Operations Funding Allocation



Subprogram	Allocation
Environmental & Safety	20%
Operations Technology	15%
System Design and Materials	40%
System Inspection & Monitoring	25%
Total	**$3,644,784**



Subprogram	Original Allocation	Revised Allocation
Environmental & Safety	20%	22%
Operations Technology	15%	18%
System Design and Materials	40%	39%
System Inspection & Monitoring	25%	21%
Total	**$3,644,784**	**$4,394,784**

Figure 3: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Gas Operations Program.

8.2 Program Benefits

Projects supported by the Gas Operations Program area deliver a wide range of benefits.

Benefit	Explanation
Reliability	Projects in this program focus on developing methods and technologies for more effective pipeline construction, alteration, and repair and on minimizing impacts to the public through avoidance of service interruptions and construction disruptions by extending the service life of the pipeline infrastructure.
Safety	Projects in this program seek to develop advanced systems to identify and mitigate threats to the pipeline system, protect pipelines from intentional and unintentional damage, and focus on various other aspects related to the safety of the public, company employees, and contractors working on or around the pipeline and system facilities.
Operational Efficiency	Projects in this program seek to identify practices that streamline processes, reduce time-on-task, leverage automation of data gathering and analytics, improve effectiveness, and develop new technologies to advance pipeline safety and regulatory compliance. Examples of such projects include developing less-invasive pipeline construction methods or more efficient operation and maintenance methods.
Improved Affordability	Projects in this program seek to drive development of technologies and innovations that reduce or avoid operational costs to increase energy affordability for ratepayers.
Environmental: Reduced GHG Emissions	Projects in this program develop technologies and best practices for reducing GHG emissions and mitigating the impacts of gas system emissions on climate change.

Environmental: Improved Air Quality	Projects in this program reduce the environmental impact of the pipeline system emissions through reducing the emissions of harmful air pollutants, such as post-combustion criteria pollutants.

8.2.1 Equity Considerations

The natural gas pipeline system serves customers regardless of their socioeconomic status. The Gas Operations Program funds a wide variety of projects applicable to all aspects of system pipeline operations. Many of this program's projects improve the efficiency of the gas pipeline and therefore its affordability. This keeps energy costs more affordable, which has a greater positive impact on ESJ community members, for which energy costs may comprise a greater share of their incomes. Importantly, many of the innovations developed by this program are adopted nationally by other utilities, which supports equity across the nation.

8.3 Environmental & Safety

8.3.1 Subprogram Overview

This subprogram seeks to advance the environmental integrity of the pipeline network and the safety of those who live and work in proximity to it. Environmental projects focus on developing technologies that also support state goals. Safety projects are concerned with protecting the pipeline from intentional and unintentional damage and improving the safety of the general public and company employees or contractors working on or around the pipeline. Projects include exploring how blending hydrogen into the pipeline impacts the operation and maintenance of the pipeline system regarding safety, reliability, integrity, and environmental impacts.

Furthermore, gas emissions monitoring and reduction research is being supported by the SoCalGas Natural Gas Leakage Abatement R&D Program under the SB 1371 compliance plan, pursuant to the Gas Leak Abatement OIR (R.15-01-008).

8.3.2 Policy Considerations

This subprogram aligns and conforms with California's decarbonization goals through its direct relevance and applicability to several key policies, including:

Policy	Description
EO B-55-18	Carbon-neutral California economy by 2045
Clean Air Act	Air quality standards for NOx and PM
AB 32	Reduce CO2 emissions 40% below 1990 levels by 2030
SB 1383	Reduce methane emissions from decomposition of organic wastes
SB 1440	Authorizes a state procurement program for biomethane
LCFS	Reduce carbon intensity of fuels by 10% by 2020
AB 8	Development of 100 hydrogen refueling stations in California

EO B48-18	200 hydrogen refueling stations in California by 2025
Cal/OSHA Title 8 CCR	Injury and Illness Prevention Program
CPUC General Order 112F	Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems
DOT 49 CFR Part 192	Federal pipeline safety regulations

8.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: System Emissions**
  Projects in this research area seek to address post-combustion criteria air pollutants and GHG emissions. This research area supports the development of advanced technologies to detect, quantify, and provide real-time monitoring of emissions. Projects also include development of technologies or systems aimed at reduction or prevention of emissions. Projects are also needed to study diverse sources of energy and the effects on system emissions. This area supports the SoCalGas policy drivers for decarbonization, digitalization, and development of a diversified portfolio of energy sources. Resolution G-3601 directed that SoCalGas consider research on gas system decommissioning. Related projects will be added to this research area for 2023 (CY 2024).

- **Area 2: Environment**
  This area includes projects related to the impact of diversified energy and to acquiring real-time information on the impact of ground subsidence and movement caused by drought and groundwater replenishment. Environmental projects focus on developing methods to prevent or mitigate contaminated water or hazardous waste run-off and preserve plants and endangered species during pipeline construction and repair within environmentally sensitive areas.
- **Area 3: Safety**
  The majority of safety incidents in the pipeline system are associated with third-party damage. Safety projects concerned with protecting the pipeline from intentional and unintentional damage include those developing 1) advanced sensors and monitoring systems to alert pipeline operators of third-party encroachment and construction activities near pipeline rights-of-way and 2) automatic shutoff systems for above- and belowground piping systems. Safety projects related to worker safety include those advancing training technologies and knowledge transfer.

8.3.4 Revised Funding Table

Revisions pursuant to Res. G-3601:

Gas Operations Program		
Environmental & Safety Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**

Committed Funds for 2023	$432,844	-
Actual Incurred Cost Jan-Nov 2023	-	$337,129
Funds for Project Under Development for 2023	$296,113	$391,828
Reallocated Funds from Available Funding	-	$250,000
Total Sub-program Funding for 2023	$728,957	$978,957
Sub-program Percentage of Funding	20%	22%

8.4 Operations Technology

8.4.1 Subprogram Overview

This subprogram advances and develops advanced techniques for the construction, operation, maintenance, rehabilitation, and testing of gas pipelines and systems that facilitate continued safe and reliable service. It also supports technologies that improve employee training and explores how to prevent gas leaks that result from blending hydrogen into the pipeline.

8.4.2 Policy Considerations

Operations Technology projects support these key policies and regulations:

Policy	Description
DOT 49 CFR Part 192	Federal pipeline safety regulations
CPUC General Order 112F	Gas Transmission & Distribution rule
AB 32	GHG emission reduction targets
AB 1900	Biomethane quality standards
D.14-06-007	Approved SoCalGas' Pipeline Safety Enhancement Program

8.4.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Steel and Plastic Pipeline Construction, Operations, and Repair Technologies**
  Projects in this area would develop cost-effective polyethylene (PE) or steel pipe repair technologies that improve the efficiency of maintaining the integrity of the infrastructure. Projects in this area could also determine construction best practices for maintaining system integrity, such as how to eliminate strain on pipelines during installation. These projects improve the efficiency of maintaining the integrity of the infrastructure. Projects in the area also align with state goals to reduce GHG emissions by eliminating excessive methane emissions.
- **Area 2: Mapping and Locating Technologies**
  Projects in this area would improve pipeline locating and mapping technologies through, for example, further enhancement of acoustic, electromagnetic, and ground probing radar systems to produce complete accurate images of buried substructures. Other projects in this area could develop technologies for mapping underground pipelines and improving pipeline asset management. GIS mapping technologies are designed to improve the safety and integrity of underground natural gas pipelines by increasing the accuracy and availability of pipeline

location information in areas where traditional methods and technology are inadequate. These technologies could help address excavation damage incidents caused by insufficient or inaccurate mapping methodologies. This research area supports the SoCalGas goal of digitalization, which includes the deployment of advanced technologies and analytics to improve planning, safety, resiliency, and the integration of real-time information to benefit participants across the energy value chain.

- **Area 3: Measurement, Equipment and Tools**
  Projects in this area would validate the capabilities of state-of-the-art measurement equipment and devices for both natural gas and other constituents, such as trace constituents in RNG. Through evaluation and testing of new methane hydrogen blend leak detection equipment, this research area supports the SoCalGas goals of decarbonization and diversity of energy. Resolution G-3601 directed that SoCalGas consider research on cybersecurity. Therefore, projects related to operations cybersecurity are being added to this research area.

8.4.4 Revised Funding Table

Revisions pursuant to Res. G-3601:

Gas Operations Program Operations Technology Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$299,844	-
Actual Incurred Cost Jan-Nov 2023	-	$264,851
Funds for Project Under Development for 2023	$246,874	$281,867
Reallocated Funds from Available Funding	-	$250,000
Total Sub-program Funding for 2023	$546,718	$796,718
Sub-program Percentage of Funding	15%	18%

8.5 System Design & Materials

8.5.1 Subprogram Overview

The objectives of this subprogram are to advance materials and materials science, materials tracking and traceability, and technical tools for designing pipeline systems and infrastructure for safety, reliability, efficiency, and maintainability throughout the life cycle of pipeline assets. Projects include research to advance engineering design standards and models, developing risk analytical tools to comply with pipeline integrity regulations, modeling operational efficiencies of gas storage and compressor station assets, and assessing the effects of incorporating gas from nontraditional sources (biogas ~~and hydrogen-blend~~) on overall natural gas quality and system integrity. Ultimately, lessons learned on these projects help SoCalGas better design, engineer, and develop its pipeline system.

Revisions pursuant to Res. G-3601:

Per Res. G-3601, research in the area of hydrogen-blending has been removed from this subprogram. See Appendix E for details on the applicable projects.

8.5.2 Policy Considerations

System Design & Materials projects support key policies and regulations:

Policy	Description
AB 32	Reduce CO2 emissions 40% below 1990 levels by 2030
CPUC General Order 112F	Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems
DOT 49 CFR Part 192	Federal pipeline safety regulations
AB 1900	Biomethane quality standards
Biomethane OIR Phase 3 (R.13-02-008)	Biomethane standards and requirements
ASME B31.8	Gas transmission and distribution piping systems
~~OIR R.13-02-008, Phase 4~~	~~Addresses injection of renewable hydrogen into gas pipelines~~

8.5.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Gas Composition and Quality**
  Natural gas quality affects the integrity and safety of the pipeline infrastructure and end-use combustion equipment. RNG from non-conventional sources contains trace constituents that can impact pipeline integrity and customer combustion equipment performance. RNG-related research projects in this area will seek to identify trace constituents and support establishment of upper limits for accepting RNG. ~~Hydrogen-related research projects would identify technologies that could enable the introduction and blending of 10-20% hydrogen into existing pipeline infrastructure.~~ In addition, projects in this area could develop cost-effective, miniature online volatile organic compound (VOC) and siloxane analyzers that have the detection levels and accuracies of laboratory equipment. This research area supports the SoCalGas goals of decarbonization and the development of a diversified portfolio of clean energy sources.
- **Area 2: System Design**
  Projects in this research area seek to improve the understanding of the implications of potential risk factors, such as stresses due to internal gas pressure, construction procedures, and environmental factors (corrosive and geohazards). Integrating this understanding with analytics of materials that mitigate these risks enables improvements in system design that can mitigate risks prior to installation. Development of metal loss criteria for anomalies in the pipeline enables the establishment of acceptable limits for pipelines operating at various pressures, which in turn enables the redesign of pipeline specifications and repair

solutions to maintain system integrity. In addition, projects that focus on external loads—such as geohazards or construction hazards—create opportunities to better understand the stresses these hazards would potentially place on the pipeline, enabling these factors to be incorporated into the original design or retrofitted into legacy pipeline segments. Enhancing pipeline integrity addresses SoCalGas' decarbonization initiative by reducing the risk of pipeline damage that can cause methane emissions and determining impacts to the system infrastructure with the new diversified energy sources.

- **Area 3: Materials**
  Projects in this area will analyze state-of-the-art materials and coatings to identify those that can improve the longevity and therefore the reliability of newly installed pipeline segments over that of legacy installations. Area 3 projects could also help identify materials and coatings that are suitable for internal and external environments—knowledge that is key to maintaining a safe and reliable pipeline system. Understanding the advancements of both pipeline and weld materials will enable appropriate selections for the wide variety of environmental scenarios to which the pipeline will be exposed. With the acceptance ~~of hydrogen and~~ RNG as key initiatives, work is being done to understand which materials would complement the anticipated change in the internal environment of the pipeline to maintain the integrity of the legacy system as well as incorporate that information into material selection for future designs of newly constructed segments. Research efforts for tracking and traceability projects improve the data collection of materials by developing an approach to streamline the traceability of steel assets and a marking standard for pipeline components.

8.5.4 Revised Funding Table

Revisions pursuant to Res. G-3601:

Gas Operations Program		
System Design & Materials Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$1,025,964	-
Actual Incurred Cost Jan-Nov 2023	-	$701,750
Funds for Project Under Development for 2023	$431,950	$756,163
Reallocated Funds from Available Funding	-	$250,000
Total Sub-program Funding for 2023	$1,457,913~~4~~	$1,707,913
Sub-program Percentage of Funding	40%	39%

8.6 System Inspection & Monitoring

8.6.1 Subprogram Overview

The objectives for this subprogram include developing technologies and methods for inspection, monitoring, and testing of pipelines and pipeline components to assess the condition and performance of pipeline facilities. The goal is to improve system performance, reliability, safety, and operational efficiencies through data management to identify precursors to failures or incidents. Projects in this subprogram area leverage AI, machine learning, preventive and predictive maintenance technologies, including data analytic models and data lakes. Projects include innovative data sources such as Crowd Source and the Internet of Things (IoT). This subprogram also seeks to explore tools for managing the potential impacts of blending hydrogen into the gas pipeline.

8.6.2 Policy Considerations

System Inspection & Monitoring projects support key policies and regulations:

Policy	Description
AB 32	Reduce CO2 emissions 40% below 1990 levels by 2030
CPUC General Order 112F	Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems
DOT 49 CFR Part 192	Federal pipeline safety regulations
Clean Air Act	Air quality standards for Nox and PM

8.6.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Pipeline Systems Inspection Technologies**
  Projects in this area improve pipeline inspection technologies such as in-line and non-destructive examination (NDE). Projects continuing for 2023 include enhancing modules or sensors detection capabilities and extending the inspection range for the Explorer robotic platform, and with developing non-destructive inspection technologies like using THz methods to interpret PE butt-fusion joint defects with 2D and 3D reconstruction imaging.
- **Area 2: Remote Pipeline Monitoring Systems**
  Projects in this area include the evaluation of remote inspection and monitoring systems. These non-intrusive technologies include satellite, aerial (manned and unmanned), and aboveground measurement of ground subsidence, methane emissions, distressed or dead vegetation, pipeline coating condition, and corrosion.
- **Area 3: Data Analytics**
  Digitalization of system information and advancing the use of data analytics are key strategies for improving system safety, reliability, and integrity in addition to being a pathway for achieving operational efficiency and emissions reductions. Leveraging machine learning, AI, image recognition, virtual and augmented reality technologies, neural networks, and advanced connectivity through social networks and IoT are examples of technologies that are being leveraged in a variety of research areas and proposals that are under development.
- **Area 4: Geohazard Threat Inspection and Monitoring**
  Projects in this area seek to monitor environmental threats, such as weather-related landslides and floods as well as seismic ground faults impacting pipeline integrity. This technology can provide continuous real-time measurement of strain imposed on the pipeline and alert pipeline operators to take mitigative measures to avoid pipeline failures. This research area supports the SoCalGas goal of digitalization.

8.6.4 Revised Funding Table

Revisions pursuant to Res. G-3601:

Gas Operations Program		
System Inspection & Monitoring Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$686,563	-
Actual Incurred Cost Jan-Nov 2023	-	$1,729,281
Funds for Project Under Development for 2023	$224,633	$0
Reallocated Funds from Available Funding	-	$0
Total Sub-program Funding for 2023	$911,196	$911,196
Sub-program Percentage of Funding	25%	21%

9 CLEAN TRANSPORTATION

The Clean Transportation Program area supports activities that minimize environmental impacts related to the transportation sector through the development of low-carbon fuels, zero-emissions drivetrains, fueling infrastructure, and on-board storage technologies. Other key objectives of this RD&D program area are to develop:

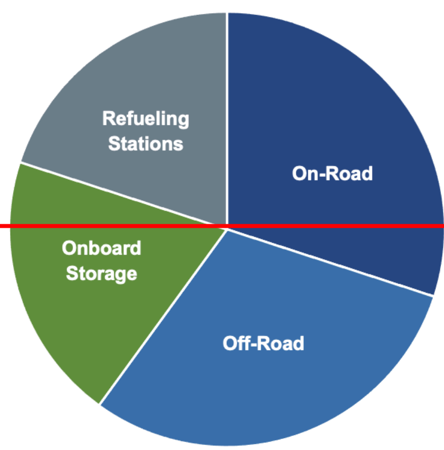
- Zero-emission transportation technologies
- Gaseous fueling infrastructure
- Advanced onboard storage technologies

The program invests in technology development projects in the following subprograms: 1) Off-Road, 2) On-Road, 3) Refueling Stations, and 4) Onboard Storage.

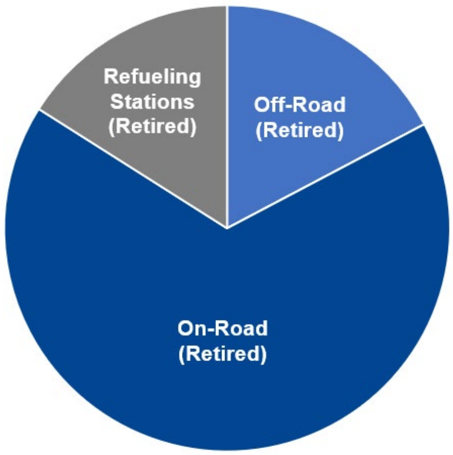
9.1 Proposed 2023 Clean Transportation Funding Allocation

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Off-Road, On-Road, Refueling Stations, and Onboard Storage subprograms in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for Off-Road, Onboard Storage, On-Road, and Refueling Stations includes actual and estimated incurred costs prior to the issuance of Res. G-3601.



Subprogram	Allocation
Off-Road	30%
Onboard Storage	20%
On-Road	30%
Refueling Stations	20%
Total	**$2,126,124**



Subprogram	Original Allocation	Revised Allocation
Off-Road (Retired)	30%	17%
Onboard Storage (Retired)	20%	0%
On-Road (Retired)	30%	67%
Refueling Stations (Retired)	20%	16%
Total	**$2,126,124**	**$1,134,579**

Figure 4: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Clean Transportation Program.

9.2 Off-Road (Retired)

9.2.1 Subprogram Overview

This subprogram targets emissions reductions from off-road vehicles such as rail, ocean-going vessels and commercial harbor craft, and construction and cargo handling equipment, where gaseous fuels can reduce emissions. Subprogram staff have also begun to explore aviation applications, including hydrogen fuel cell aircraft and drones. The subprogram focuses on developing zero-emission off-road transportation solutions using renewable hydrogen and RNG.

Revisions pursuant Res. G-3601:

SoCalGas is retiring the Off-Road subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.1.6.

9.2.2 Policy Considerations

This subprogram aligns and conforms with several of California's decarbonization goals:

Policy	Description
EO N-79-20	100% zero-emission off-road vehicles and equipment by 2035 where feasible
CARB Clean Fleets Rule	Establishes a medium- and heavy-duty zero-emission fleet regulation with the goal of achieving a zero-emission truck and bus California fleet by 2045 where feasible
CARB At-Berth Regulations	Reduce diesel PM and Nox emissions from the auxiliary engines of ocean-going vessels while they are docked at California ports

9.2.3 2023 Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Zero-Emission Technology for Rail**
  For decades, diesel fuel has been the only realistic way to meet the demanding operating requirements in rail. As the demand for zero-emission transportation increases, alternative technologies continue to be the right solution for customers around the globe. Hydrogen fuel cells are recognized as one of the innovative solutions necessary for a carbon-neutral future, generating enough energy to power passenger and cargo trains. R&D in this area will help provide emission reductions that meet or exceed regulatory requirements. Fuel cell trains will play a key role in the transition to a zero-emission economy. Hydrogen-powered trains are poised to disrupt the rail industry as a cost-effective, high-performing, zero-emission alternative to diesel.
- **Area 2: Zero-Emission Technology for Marine**
  Off-road mobile sources account for over 40% of Nox emissions in the South Coast Basin. The marine industry is subject to new, stringent emissions standards. In addition, hoteling and shore-power for marine applications is a significant source of emissions in the basin. R&D in this area will help provide emission reductions that are surplus to regulatory requirements.
- **Area 3: Zero- and Near-Zero-Emission Technology for Construction Equipment**
  New diesel engines manufactured in the United States for construction vehicles such as wheel scrapers and wheel dozers are required to meet the EPA Tier 4 off-road standard of approximately 0.3 grams per brake horsepower-hour (g/bhp-hr) for Nox. In California, regulatory and competitive pressures are motivating fleet owners to convert their older (Tier 3 or less) machines to Tier 4. Most older machines cannot be repowered (replace older engine with new one) to Tier 4 because the manufacturer does not have a Tier 4 retrofit package. Research in this area will help construction equipment and fleets meet Tier 4 standards in a cost-effective manner.
- **Area 4: Zero-Emission Technology for Aviation**
  Airlines have committed to carbon-neutral growth in international commercial aviation beginning in 2021. U.S. airlines have set a goal to achieve net-zero carbon emissions by 2050.[39] Although U.S. airlines have improved efficiency by 130% compared to 1978 levels, additional efficiency improvements in planes and engines are not likely to be enough. Meeting the 2050 goal will require fuels that have a lower carbon footprint. Hydrogen, with three times the energy density per mass of traditional jet fuel, is increasingly considered as one of the most promising zero-emission technologies for future aircraft.

9.2.4 Subprogram Benefits

Benefit	Explanation
Reliability	Fuel-cell electric vehicles (FCEVs) could reduce dependence on foreign oil because hydrogen can be derived from domestic sources, including renewable sources such as water, biogas, and agricultural waste. Zero-emission vehicles (ZEVs) require less maintenance than their gasoline and diesel counterparts.

[39] See*, for example*, Airlines for America - https://www.airlines.org/airlines-fly-green/

Benefit	Explanation
Operational Efficiency	ZEVs require less maintenance and can refuel in the same amount of time as their diesel counterparts. FCEVs operate at higher fuel efficiency (60%) than internal combustion counterparts (20–30%).
Improved Affordability	ZEVs can benefit from incentives such as the LCFS.
Environmental: Reduced GHG Emissions	RNG and hydrogen fuel significantly reduce GHG emissions compared to diesel.
Environmental: Improved Air Quality	Vehicles emit a significant fraction of the air pollutants that contribute to smog and harmful particulates in California. Zero-emissions vehicles produce no tailpipe Nox or PM emissions.

9.2.5 Equity Considerations

ESJ communities are disproportionately affected by both mobile and stationary source (MSS) pollution. MSS reductions will highly benefit ESJ communities. This subprogram seeks rapid transition to zero-emission technology in and near ESJ communities, complementing AB 617 strategies and consistent with CARB's equity goals.[40]

9.2.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Transportation Program Off-Road Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$273,949	-
Actual Incurred Cost Jan-Nov 2023		$21,036
Funds for Project Under Development for 2023	$363,888	$0
Estimated Incurred Cost Jan-Nov 2023[(a)]	-	$175,000
Total Sub-program Funding for 2023	$637,837	$196,036
Funds Available for Reallocation	-	$441,801
Sub-program Percentage of Funding	30%	17%

[(a)]Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

9.3 Onboard Storage (Retired)

9.3.1 Subprogram Overview

This subprogram targets the development, demonstration, and deployment of cost-effective technologies and systems that improve onboard storage for gaseous transportation fuels. Areas of focus include advanced materials, low-pressure systems, and conformable tanks for both compressed natural gas (CNG) and hydrogen. Onboard storage, which requires compressed storage and/or the use of advanced adsorption

[40] California Air Resources Board "2020 Mobile Source Strategy"

technologies, is a critical element needed for increased utilization of low-carbon, low-emission gaseous fuels.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Onboard Storage subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.3.6.

9.3.2 Policy Considerations

Onboard Storage projects support multiple policies and regulations. Advancements In onboard hydrogen storage tanks for on-road and off-road applications can help reduce the size, weight, and cost of hydrogen vehicles. This can also increase range and efficiency to make hydrogen more favorable in different applications.

Policy	Description
EO B-48-18	5 million ZEVS by 2030; 200 hydrogen refueling stations by 2025
EO N-79-20	Eliminate new internal combustion engine vehicles by 2035; 100% light-duty vehicles and drayage trucks sold will be zero-emission by 2035; 100% MHD vehicles sold and operated are zero-emission by 2045

9.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Conformable and Low-Pressure Tanks**
  Projects in this area research improvements in the capacity, conformability, safety, and cost of on-board storage of gaseous fuels through development of conformable and low-pressure tanks. They will also research fueling protocols and applications to allow faster and fuller fills for RNG and renewable hydrogen.

9.3.4 Subprogram Benefits

Benefit	Explanation
Reliability	Low-pressure and advanced onboard storage tanks can provide greater cycle life and reduce required load on infrastructure.
Safety	Advanced materials can help store fuel at lower pressures and meet highest safety requirements of high-pressure storage vessels.
Operational Efficiency	Higher absorption and desorption materials can help reduce refueling times and fuller fills to maximize range and efficiency.
Improved Affordability	Low-pressure storage tanks require less compression and power needed to operate, and advanced onboard tanks help decrease costs.

Environmental: Reduced GHG Emissions	RNG and hydrogen fuel reduce GHGs given their lower carbon intensity relative to diesel.
Environmental: Improved Air Quality	Low-pressure storage tanks require less compression and power needed to operate.

9.3.5 Equity Considerations

"Investment in zero-emission transportation cannot be limited to electric cars, which are beyond the financial reach of many Californians. It must also be directed to clean transit, which will greatly benefit disadvantaged communities."[41]

9.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Transportation Program Onboard Storage (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$29,855	-
Actual Incurred Cost Jan-Nov 2023	-	$0
Funds for Project Under Development for 2023	$395,370	$0
Estimated Incurred Cost Jan-Nov 2023 [(a)]	-	$0
Total Sub-program Funding for 2023	$425,225	$0
Funds Available for Reallocation	-	$425,225
Sub-program Percentage of Funding	20%	0%

[(a)] Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

9.4 On-Road (Retired)

9.4.1 Subprogram Overview

This subprogram targets emissions reductions from medium- and heavy-duty (MHD) on-road vehicles. The focus is on-road transportation technologies using renewable hydrogen and RNG.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the On-Road subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.4.6.

9.4.2 Policy Considerations

On-Road research projects support multiple policies and regulations:

[41] https://blog.ballard.com/public-transport-access

Policy	Description
EO B-48-18	5 million ZEVs by 2030; 200 hydrogen refueling stations by 2025
EO N-79-20	Eliminate new internal combustion engine vehicles by 2035; 100% light-duty vehicles and drayage trucks sold will be zero-emission by 2035; 100% MHD vehicles sold and operated are zero-emission by 2045
CARB Clean Truck Rule	100% ZEV where feasible for drayage, public fleets, last-mile delivery by 2045
CARB Clean Fleet Rule	100% zero-emission trucks and buses where feasible by 2045

9.4.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Hydrogen Fuel Cell Development for MHD Trucks**
  Projects in this area perform research in advanced hydrogen fuel-cell electric vehicles (FCEVs) and zero-emission technologies for MHD freight and people transportation. Projects also demonstrate zero-emission vehicles (ZEVs) to encourage adoption of such technologies.
- **Area 2: Pathways for Zero-Emission Vehicles and Sustainable Transportation**
  Projects in this area perform studies on and assessments of advanced hydrogen FCEVs and zero-emission technologies for goods movement, transit, and transportation. Projects will also look at total cost of ownership, techno-economic analyses, planning, and roadmaps toward the adoption of ZEVs.
- **Area 3: Advanced Innovation and Connected Vehicles**
  Projects in this area perform research in state-of-the-art sustainable transportation technologies such as connected and autonomous vehicles (CAVs) to increase efficiencies in goods movement, public transportation, and ZEVs. Projects also demonstrate emissions reductions and efficiencies related to the adoption of CAVs.

9.4.4 Subprogram Benefits

Benefit	Explanation
Reliability	FCEVs could reduce U.S. dependence on foreign oil because hydrogen can be derived from domestic sources, including renewable sources such as water, biogas, and agricultural waste. ZEVs require less maintenance than their gasoline and diesel counterparts.
Operational Efficiency	ZEVs require less maintenance and can refuel in the same amount of time as their diesel counterparts. FCEVs operate at higher fuel efficiency (60%) than their internal combustion counterparts (20–30%).
Environmental: Reduced GHG Emissions	RNG and hydrogen fuel significantly reduce GHG emissions compared to diesel.

Environmental: Improved Air Quality	Vehicles emit a significant fraction of the air pollutants that contribute to smog and harmful particulates in California. Zero-emissions vehicles produce no Nox or PM emissions.

> "Reducing NOx emissions is vital to public health. As a precursor to smog, NOx can cause or worsen numerous respiratory and other health ailments and is also associated with premature death. All combustion engines produce NOx, and although technology has advanced markedly over the years, California must still do more to reduce NOx emissions from mobile sources, especially trucks."
>
> —California Air Resources Board

9.4.5 Equity Considerations

By seeking to develop zero-emissions MHD on-road vehicles, which frequently operate in ESJ communities, this subprogram will not only improve air quality, but also reduce GHG emissions—which will help reduce the impact of climate change. This program also supports development of zero-emission clean transit solutions, which typically benefit residents of ESJ communities more than other groups.

9.4.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Transportation Program On-Road Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$405,782	-
Actual Incurred Cost Jan-Nov 2023	-	$556,841
Funds for Project Under Development for 2023	$232,055	$0
Estimated Incurred Cost Jan-Nov 2023 [a]	-	$200,000
Total Sub-program Funding for 2023	$637,837	$756,841
Funds Available for Reallocation	-	$(119,004)[b]
Sub-program Percentage of Funding	30%	67%

[a] Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

[b] Funds available for reallocation are negative because some of the services rendered prior to the issuance of Res. G-3601, included in the "Estimated Incurred Costs Jan-Nov 2023" line, were performed towards milestones planned to be completed and paid in 2024 and beyond.

9.5 Refueling Stations (Retired)

9.5.1 Subprogram Overview

This subprogram targets the development, demonstration, and deployment of technologies and systems that support refueling for alternative fuels, including renewable hydrogen and RNG. The subprogram seeks to identify and manage concerns and issues arising from refueling of gaseous fuels—from storage to safety and standardization.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Refueling Stations subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 9.5.6.

9.5.2 Policy Considerations

Refueling Stations projects support multiple policies and regulations:

Policy	Description
AB 8	100 Hydrogen Refueling Stations in California
EO B-48-18	5 million ZEVs by 2030; 200 hydrogen refueling stations by 2025
Low Carbon Fuel Standard	Reduce carbon intensity in transportation fuels as compared to conventional petroleum fuels, such as gasoline and diesel

9.5.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Advanced Full Fill Technologies**
  Fast fill of compressed gas generates heat, which prevents full fill of the storage tank. Advanced full fill technologies help resolve this issue to provide full fills to CNG and hydrogen FCEVs. This helps alleviate range anxiety and promotes wider adoption of gaseous vehicles that significantly reduce emissions versus their liquid fuel counterparts.
- **Area 2: Hydrogen Refueling Station Optimization and Safety**
  Although hydrogen FCEVs have been researched and demonstrated, optimizing refueling infrastructure would enable broader adoption of these vehicles by transit and goods movement fleets. This research will look at improving hydrogen compressors, increasing the efficiency of overall refueling stations, and alternative technologies for refueling stations. Hydrogen and CNG as transportation fuel operate at high pressures: 10,000 pounds per square inch (psi) and 3,600 psi, respectively. Safety and standardization for station technologies are imperative for the successful adoption of both natural gas vehicles (NGVs) and FCEVs. Safety of refueling stations and components is a top priority for the station and vehicle operators of ZEVs.

9.5.4 Subprogram Benefits

Benefit	Explanation
Reliability	FCEVs could reduce U.S. dependence on foreign oil because hydrogen can be derived from domestic sources, including renewable sources such as water, biogas, and agricultural waste.
Safety	Technologies to reduce and mitigate potential risks in near-zero and zero-emission infrastructure to be as safe as gasoline stations.
Operational Efficiency	Optimizing refueling stations can decrease refueling times and supplement fueling for on-road vehicles and nearby buildings through distributed energy resources.
Improved Affordability	Optimizing refueling stations can decrease needed power for compressors and other equipment to reduce costs.
Environmental: Reduced GHG Emissions	RNG and renewable hydrogen fuel reduce GHGs given their lower carbon intensity relative to diesel.
Environmental: Improved Air Quality	Optimizing refueling stations can decrease emissions from additional devices that are essential to deliver the hydrogen to customers.

9.5.5 Equity Considerations

By seeking to develop technologies that enable deployment of hydrogen fueling infrastructure, this sub-program supports a broader deployment of FCEV's in all communities. However, since the effects of transportation pollution, including higher rates of asthma, are more pronounced in low-income communities,[42] supporting the deployment of zero emission transportation could help reduce air pollution and save up to 6,000 lives per year.[43]

9.5.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Transportation Program
Refueling Stations Sub-program (Retired) **2023 Funding Allocation**

[42] https://www.uclahealth.org/news/asthma-disproportionately-affects-low-income-populations
[43] https://www.nature.com/articles/news050620-12

	Initial Allocation	Revised pursuant to Res G-3601
Committed Funds for 2023	$29,855	-
Actual Incurred Cost Jan-Nov 2023	-	$118,263
Funds for Project Under Development for 2023	$395,370	$0
Estimated Incurred Cost Jan-Nov 2023 [(a)]	-	$63,439
Total Sub-program Funding for 2023	$425,225	$181,702
Funds Available for Reallocation	-	$243,523
Sub-program Percentage of Funding	20%	16%

[(a)]Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

10 CLEAN GENERATION

The Clean Generation program area targets the development and demonstration of high-efficiency products and technologies associated with the generation of power for the residential, commercial, and industrial market segments to reduce emissions, lower customer costs, integrate renewable fuels, and improve energy reliability and resiliency. Other key objectives of this Clean Generation program area are to:

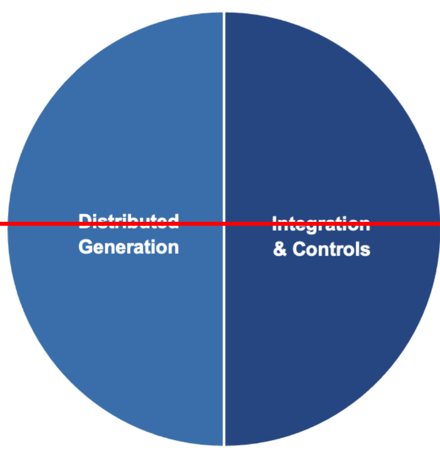
- Improve energy reliability and resiliency
- Reduce emissions of distributed generation (DG) technologies
- Reduce customer cost
- Improve DG integration and microgrid controls

The program invests in technology development projects in the following subprograms: 1) Distributed Generation and 2) Integration & Controls.

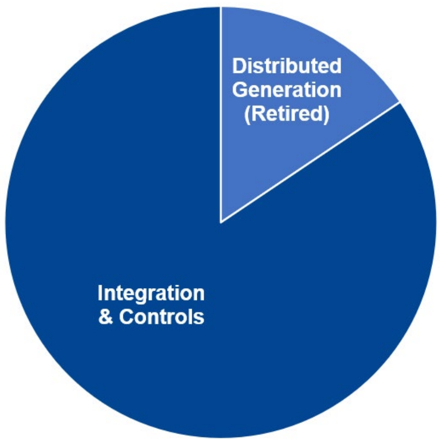
10.1 Proposed 2023 Clean Generation Funding Allocation

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Distributed Generation subprogram in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for Distributed Generation includes SoCalGas's existing contractual obligations for projects that are currently ongoing, as authorized by Res. G-3601.



Subprogram	Allocation
Distributed Generation	50%
Integration & Controls	50%
Total	**$1,670,526**



Subprogram	Original Allocation	Revised Allocation
Distributed Generation (Retired)	50%	16%
Integration & Controls	50%	84%
Total	**$1,670,526**	**$2,061,741**

Figure 5: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Clean Generation Program.

10.2 Distributed Generation (Retired)

10.2.1 Subprogram Overview

This subprogram seeks to develop and enhance DG technologies. New DG technologies are needed to improve energy reliability and resilience and to incorporate increasing quantities of RNG and hydrogen.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Distributed Generation subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 10.2.6.

10.2.2 Policy Considerations

This subprogram develops reliable DG technologies with high efficiencies and increased RNG and hydrogen tolerance, resulting in reduced or eliminated emissions. Through these pathways, this subprogram supports several key policies.

Policy	Description
CPUC R.19-09-009	Microgrids and resiliency proceeding
AB3232	Building decarbonization
SB32	Reduce CO_2 emissions
Clean Air Act	Air quality standards for Nox and PM
SB 100	Zero-carbon electricity by 2045
EO B-55-18	Carbon-neutral California economy by 2045
SB 1298	DG regulation
SGIP	Self-Generation Incentive Program

10.2.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Commercialization of Small Scale (less than 50 kilowatt) Solid Oxide Fuel Cells (SOFCs)**
  Projects in this area seek to commercialize SOFCs for residential and small commercial customers. Small-scale SOFC units are widely available in Japan and Europe and recently are becoming increasingly available in South Korea. There are currently no commercially available small SOFCs in the United States. Lab testing, field demonstrations, system optimization, and safety certifications are required to introduce these products into the U.S. market.
- **Area 2: Hydrogen Integration with Existing Power Generation Technologies**
  Projects in this area seek to continue to test and identify pathways for increased levels of hydrogen blending for fuel cell, engine, and turbine-based DG technologies currently operating on natural gas. Identifying and increasing hydrogen thresholds of existing DG equipment is a critical component of meeting California's building decarbonization goals.
- **Area 3: Development of Low-emission CHP and Backup Generation**
  Projects in this area seek to develop and demonstrate low-emissions DG technologies that can help customers maintain energy resilience year-round, including during public safety power shutoff (PSPS) events and other grid disturbances, while limiting GHG and criteria pollutant emissions.

10.2.4 Subprogram Benefits

Benefit	Explanation
Reliability	Gas-fueled DG has the ability to provide highly reliable and resilient electricity to customers by enabling them to be partially or completely independent of the electric grid, when needed.
Operational Efficiency	Combined heat and power (CHP) systems have the ability to maximize customers' operational efficiency by productively using "waste heat," often offsetting other heating- and cooling-related energy consumption.
Improved Affordability	By improving the overall efficiency of DG technologies and microgrids, customer energy costs are reduced.
Environmental: Reduced GHG Emissions	Improving the efficiency (reduced fuel utilization) and increasing hydrogen tolerance of DG technologies result in lower GHG emissions.
Environmental: Improved Air Quality	Projects in this subprogram specifically focus on developing and demonstrating technologies that can meet or exceed CARB-DG certification standards, resulting in improved air quality.

10.2.5 Equity Considerations

Low-emission, DG technologies can provide energy resilience to vulnerable populations, such as medical baseline customers, during power outages—including those resulting from PSPS events. Deployment of diesel-replacing DG within industrial areas adjacent to low-income communities (LICs) improves air quality.

10.2.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Generation Program Distributed Generation Sub-program (Retired) 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$137,763	-
Actual Incurred Cost Jan-Nov 2023	-	$196,334
Funds Needed to Complete In-Progress Projects	-	$125,000
Funds for Project Under Development for 2023	$697,500	$0
Total Sub-program Funding for 2023	$835,263	$321,334
Funds Available for Reallocation		$513,929
Sub-program Percentage of Funding	50%	16%

10.3 Integration & Controls

10.3.1 Subprogram Overview

This subprogram develops, enhances, and demonstrates technologies and control systems that integrate diverse DG resources and thermal loads. The focus is on enabling low-emissions, DG, and storage technologies to provide energy resilience and affordability to customers.

10.3.2 Policy Considerations

This subprogram aims to increase energy resilience and reduce customer emissions through the optimization of a “fully integrated energy system,” leveraging and optimizing the utilization of low-emissions gas-fueled DG (such as fuel cells), on-site renewable generation, energy storage, and thermal systems. Integration & Controls projects support multiple policies and regulations:

Policy	Description
SB 1339	Microgrids for increased electricity reliability
CA Title 24	Buildings Energy Efficiency
CPUC R.19-09-009	Microgrids and Resiliency proceeding
AB3232	Building Decarbonization
SB 100	GHG emissions
Clean Air Act	Air quality standards for Nox and PM
EO B-55-18	Carbon neutral economy by 2045

10.3.3 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Integration and Optimization of Fuel Cells with Existing Customer Electric and Heating Systems**
  Projects in this area seek to develop and demonstrate hardware and software that enable the optimal integration of fuel cells with existing electric (including solar and battery storage) and heating systems at customer sites. Microgrids are typically highly customized, which results in high implementation costs. Identifying and demonstrating off-the-shelf components to simplify installations for customers will ideally reduce cost and other Integration complications. System complexity and lack of clear hardware requirements are significant barriers to adoption.
- **Area 2: Integration of Low-emissions Backup Generation with Existing Customer Electrical Systems to Provide Energy Resilience**
  Projects in this area seek to demonstrate how low-emissions backup generation can be seamlessly integrated with existing customer systems to provide increased resilience. This topic is targeted toward the integration of intermittent/backup generation with existing systems. With the increasing regularity of wildfires (and resulting PSPS events), customers and agencies are looking for alternatives to diesel backup generation and clarity on how low-emissions natural gas– or hydrogen-fueled generation technologies can address this need.
- **Area 3: Development of Technologies that Improve the Overall Efficiency of CHP Systems**
  Projects in this area seek to develop and demonstrate new technologies that optimize the utilization of “waste heat” from combined heat and power (CHP) systems. Improving the total efficiency of a CHP system by using a CHP system’s heat can improve the emissions and economics of a fully integrated energy system.
- **Area 4: Development of Technologies that Improve Cybersecurity of Integrated Energy Systems**
  Projects in this area seek to research the needs and opportunities associated with improving cybersecurity in connected DG and microgrid technologies as well as to develop new technologies. With emerging fuel cells and microgrid technologies being connected to the cloud for remote monitoring and control purposes, there is a growing need to address potential cybersecurity concerns and threats.

10.3.4 Subprogram Benefits

Benefit	Explanation
Reliability	Ensuring that customer energy systems are integrated and optimized improves power reliability and resilience. Improving grid interaction of DG also improves reliability on both sides of the meter.
Safety	When power reliability and resilience are increased, customer safety is improved due to the ability to keep critical equipment, such as HVAC or medical devices, operating during grid outages.
Operational Efficiency	Optimizing the integration of gas-fueled DG with existing customer power systems and heating

	technologies ultimately improves the overall energy efficiency for a customer.
Improved Affordability	Developing "off-the-shelf" solutions for DG integration can reduce installation costs. In addition, the development of improved control systems can reduce customer energy costs.
Environmental: Reduced GHG Emissions	Optimizing the integration of low-emissions DG, such as fuel cells, with solar + storage and heat-driven appliances can greatly reduce CO_2 emissions by providing on-site electricity that is cleaner than grid-sourced electricity and potentially offset gas consumption when CHP is optimally utilized.
Environmental: Improved Air Quality	Integrating low-emissions DG, such as fuel cells, with solar + storage and heat-driven appliances can greatly reduce criteria pollutants (Nox) by providing on-site electricity that is cleaner than grid-sourced electricity and potentially offset gas consumption when CHP is optimally utilized.

10.3.5 Equity Considerations

By simplifying and standardizing DG integration, installation costs will decrease, making resilience and energy efficiency more affordable. In addition, by simplifying the integration of clean generation technologies, the need for dirtier forms of backup generation decreases, resulting in improved air quality in DACs.

10.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Clean Generation Program Integration & Controls Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$756,858	-
Actual Incurred Cost Jan-Nov 2023		$433,022
Funds for Project Under Development for 2023	$78,405	$402,241
Funds Reallocated from Available Funding		$905,144
Total Sub-program Funding for 2023	$835,263	$ 1,740,407
Sub-program Percentage of Funding	50%	84%

Additional funding reallocated to the Integration & Controls subprogram supports several ratepayer benefits. Advancing the commercialization of technologies that enable microgrid deployment will provide ratepayers with increased energy reliability. Research to reduce the cost of integrating distributed generation technology within existing customer energy systems have the potential to provide ratepayers with a more affordable energy supply. Streamlining the integration of low- or zero-emissions distributed generation technology will create environmental benefits for ratepayers by reducing GHG emissions and criteria pollutant emissions.

Additional funding reallocated to the Integration & Controls subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given time-constraints of this program year.

11 CUSTOMER END-USE APPLICATIONS

The Customer End-Use Applications Program area focuses on developing, demonstrating, and commercializing technologies that cost-effectively improve the efficiency and reduce the environmental impacts of gas equipment used in residential, commercial, and industrial settings. Other key objectives of this program area are to:

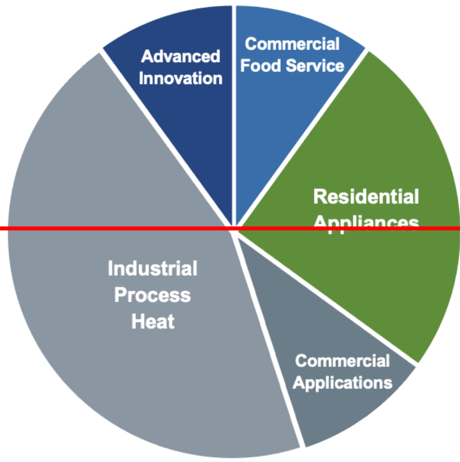
- Support the development and deployment of technologies that meet air emissions and energy efficiency goals
- Increase safety and performance while reducing cost

The program invests in technology development projects in the following subprogram areas: 1) Commercial Food Service, 2) Residential Appliances, 3) Commercial Applications, 4) Industrial Process Heat, and 5) Advanced Innovation.

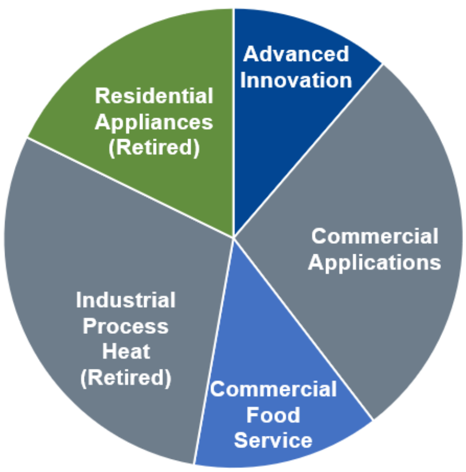
11.1 Proposed 2023 Customer End-Use Applications Funding Allocation

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Industrial Process Heat and the Residential Appliances subprograms in its 2023 RD&D Research Plan. The revised 2023 funding allocation proposed for Industrial Process Heat includes SoCalGas's existing contractual obligations for projects that are currently ongoing, as authorized by Res. G-3601. The revised 2023 funding allocation proposed for Residential Appliances includes SoCalGas' existing contractual obligations prior to the issuance of Res. G-3601.



Subprogram	Allocation
Advanced Innovation	6%
Commercial Applications	15%
~~Commercial Food Service~~	~~7%~~
Industrial Process Heat	40%
Residential Applications	32%
Total	**$2,126,124**



Subprogram	Original Allocation	Revised Allocation
Advanced Innovations	6%	11%
Commercial Applications	15%	28%
Commercial Food Service	7%	10%
Industrial Process Heat (Retired)	40%	29%
Residential Applications (Retired)	32%	21%
Total	**$2,126,124**	**$2,013,401**

Figure 6: Visual Summary of proposed 2023 Funding Allocations for Subprograms within the Customer End-Use Applications Program.

11.2 Advanced Innovation

11.2.1 Subprogram Overview

This sub-program seeks to develop new, nontraditional technologies to improve energy efficiency and decrease emissions.

11.2.2 Policy Considerations

Advanced Innovation projects support key policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency

Policy	Description
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements
LEED	Building sustainability and stewardship

11.2.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Smart Appliances**
  Projects in this research area will investigate the use of smart technology to optimize energy efficiency and reduce gas consumption. For example, projects may explore advanced construction technologies and building materials that can improve building energy efficiency or assess new innovations—such as machine learning, blockchain, 3D multi-sensor transmitters, robotics, augmented reality, or improved cybersecurity—for applicability to emissions reduction, increased efficiency, and improved safety.
- **Area 2: Advanced Materials for Building Energy Efficiency**
  Projects in this research area will investigate the use of advanced construction technologies and building materials. This includes prefabricated material, vacuum insulation panels, or phase-change glass.

11.2.4 Subprogram Benefits

Benefit	Explanation
Safety	These innovations increase customer safety by monitoring for equipment failures (for example, leaks, performance degradations, emissions increases). Reduced fuel consumption, smart air monitoring, and advanced ventilation also improve local air quality.
Operational Efficiency	These innovations aim to provide operational efficiencies by directly targeting building performance and optimizing energy systems to yield the highest total efficiency.
Improved Affordability	Identifying new technologies that provide energy efficiency results in lower customer energy costs.
Environmental: Reduced GHG Emissions	By reducing energy usage, these innovations provide environmental benefit by reducing associated GHG emissions.

Environmental: Improved Air Quality	By reducing energy usage, these innovations provide environmental benefit by reducing associated NOx and PM emissions.

11.2.5 Equity Considerations

Smart technologies and advanced building techniques and materials have the ability to provide energy efficiency at lower costs than complete retrofits. This can result in meaningful energy savings without burdensome upfront capital costs for lower income households.

11.2.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program		
Advanced Innovation Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$7,365	-
Actual Incurred Cost Jan-Nov 2023	-	$67,031
Funds for Project Under Development for 2023	$120,203	$60,537
Funds Reallocated from Available Funding		$100,059
Total Sub-program Funding for 2023	$127,568	$227,627
Sub-program Percentage of Funding	6%	11%

Additional funding reallocated to the Advanced Innovation subprogram supports several ratepayer benefits. Advancing the commercialization of technologies that enable advanced construction technology and advanced building materials will provide ratepayers with increased operational efficiency. Increased efficiency will reduce fuel consumption, providing customers with the benefits of reduced emissions and improved affordability. Moreover, the additional funding reallocated to the Advanced Innovation subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

11.3 Commercial Applications

11.3.1 Subprogram Overview

This subprogram develops and enhances technologies and advancements related to gas consumption and end uses in the commercial sector. Relevant applications include commercial HVAC, hot water service, and commercial laundry.

11.3.2 Policy Considerations

Commercial Applications projects support key policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.3.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: High-Efficiency Commercial Equipment for Building Decarbonization**
  Projects in this area seek to develop a variety of high-efficiency equipment, including commercial water heating, space conditioning, and heating, cooling, and refrigeration process equipment, with the goals of increasing energy efficiency and reducing NOx emissions.
- **Area 2: Hydrogen Blends in Commercial Equipment**
  Projects in this area seek to investigate how hydrogen blends impact the performance of commercial equipment, with particular focus on NOx emissions and energy efficiency. Projects will identify feasible modifications to equipment to accommodate higher blends.

11.3.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance for commercial equipment also provides improved operational efficiency for customers by reducing fuel cost associated with space conditions, water heating, and other commercial operations.
Improved Affordability	Increased energy efficiency improves cost savings. This reduces overhead expenditures for businesses and delivers an attractive ROI to adopt high-efficiency technologies.
Environmental: Reduced GHG Emissions	Developing advanced end-use equipment that is compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from commercial buildings.
Environmental: Improved Air Quality	Increasing energy efficiency and burner performance for commercial equipment provides an environmental benefit by reducing NOx and PM emissions.

11.3.5 Equity Considerations

Buildings are part of the community. Where office buildings are located determines who will have access to the jobs they house, how much energy they use, and how much waste they produce. Therefore, the goal of this subprogram is to provide highly efficient and socially responsible technology to the built environment that improves the quality of life for all people.

11.3.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program		
Commercial Applications Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$47,186	-
Actual Incurred Cost Jan-Nov 2023	-	$23,085
Funds for Project Under Development for 2023	$271,733	$295,834
Funds Reallocated from Available Funding	-	$250,146
Total Sub-program Funding for 2023	$318,919	$569,065
Sub-program Percentage of Funding	15%	28%

Additional funding reallocated to the Commercial Applications subprogram supports several ratepayer benefits. Advancing the development of technologies that enable increased operational efficiency will reduce fuel consumption, providing customers with the benefits of reduced emissions and improved affordability. Moreover, this additional funding reallocated to the Commercial Applications subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

11.4 Commercial Food Service

11.4.1 Subprogram Overview

This subprogram develops and enhances technologies and advancements related to commercial food service (CFS). CFS includes restaurants, catering services, and institutional kitchens that primarily rely on fuel supplied by SoCalGas for cooking and water heating. In response to the COVID-19 pandemic, this subprogram may also explore new solutions, such as adaptation to increased outdoor dining.

11.4.2 Policy Considerations

This subprogram aligns and conforms with California's decarbonization goals through its direct relevance and applicability to several key policies, including:

Policy	Description

2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.4.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Hydrogen and RNG Blends in Commercial Food Service Equipment**
  Projects in this area seek to develop highly efficient commercial food service equipment that is compatible with hydrogen and RNG blends.
- **Area 2: Low-Cost, Low-Emission Commercial Food Service Equipment**
  Projects in this area seek to develop safe, efficient, and effective technologies such as next-generation burners, gas heat pump water heaters, and kitchen ventilation systems. This area also supports projects that promote adoption of new high-efficiency equipment through technology development, demonstrations, webinars, conference presentations, and journal publications.

11.4.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance also provides improved operational efficiency for customers by reducing cooking time, increasing food output, and reducing fuel cost.
Improved Affordability	Increasing energy efficiency and burner performance results in energy cost savings and reduced total cost of ownership.
Environmental: Reduced GHG Emissions	Projects in this subprogram seek to increase energy efficiency and burner performance, which provides GHG benefit by reducing emissions from CFS equipment.
Environmental: Improved Air Quality	The CFS sector is a highly energy-intensive sector. Improved burner performance and energy efficiency significantly reduces GHG and NOx emissions.

11.4.5 Equity Considerations

Half of all American adults have worked in the restaurant industry. This subprogram seeks to reduce emissions, improve air quality, and increase profitability for an important sector that employs more minority workers than any other industry.[44]

11.4.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program		
Commercial Food Service Sub-program 2023 Funding Allocation		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$102,531	-
Actual Incurred Cost Jan-Nov 2023	-	$0
Funds for Project Under Development for 2023	$46,298	$148,829
Funds Reallocated from Available Funding		$54,880
Total Sub-program Funding for 2023	$148,829	$203,709
Sub-program Percentage of Funding	7%	10%

Additional funding reallocated to the Commercial Food Service subprogram supports several ratepayer benefits. Advancing the development of technologies that enable increased operational efficiency in cooking and water heating applications will reduce fuel consumption, providing customers with the benefits of reduced emissions and improved affordability. Moreover, this additional funding reallocated to the Commercial Food Service subprogram can be prudently and effectively deployed relatively quickly because SoCalGas has a well-established network of researchers in this area and a well-developed research project pipeline. Projects can be scoped and executed quickly to potentially provide ratepayer benefit given the time-constraints of this program year.

11.5 Industrial Process ~~Equipment~~Heat (Retired)

11.5.1 Subprogram Overview

This subprogram develops advanced heating technologies and systems for use in the industrial sector. In particular, the industrial process heat end-use sector represents some of the largest users of gaseous fuels and the most difficult applications to decarbonize. Examples include food processing, manufacturing, cement production, chemical processing, textile drying, and agriculture.

Revisions pursuant to Res. G-3601:

[44] https://restaurant.org/about/our-industry/commitment-to-diversity-equity-and-inclusion

SoCalGas is retiring the Industrial Process Heat subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 11.5.6.

11.5.2 Policy Considerations

Industrial Process ~~Equipment~~ Heat projects support key policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by 2030
SB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.5.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Heavy Industrial Process Equipment**
  This research area seeks projects that increase energy efficiency of industrial process heat applications and reduce NOx emissions. This can include high-performance burners, waste heat recovery devices, carbon capture and utilization, smart systems, and sensors.
- **Area 2: Hydrogen Blends in Industrial Equipment**
  Industrial processes, with high energy loads and high temperature requirements, are extremely difficult to electrify. Projects in this area will investigate how hydrogen blends impact the performance of industrial equipment, with particular focus on NOx emissions.

11.5.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance for industrial equipment improves operational efficiency for industrial customers by reducing fuel costs associated with high-temperature processes and improving throughput.
Improved Affordability	Developing solutions that can be implemented as modifications or retrofits to existing equipment allow for cost-effective and energy-efficient decarbonization of industrial end uses.

Environmental: Reduced GHG Emissions	Developing advanced industrial equipment that is compliant with RNG and hydrogen reduces GHG emissions from industrial processes, which are difficult and costly to electrify.
Environmental: Improved Air Quality	Increasing energy efficiency and burner performance for industrial equipment provides an environmental benefit by reducing NOx and PM emissions.

11.5.5 Equity Considerations

Industrial facilities typically neighbor LICs and DACs. This subprogram aims to improve energy efficiency and replace conventional fuels with RNG and hydrogen, which can significantly reduce emissions and improve air quality in these regions.

11.5.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program Industrial Process ~~Equipment~~ Heat Sub-program (Retired) 2023 Funding Allocation		
	Original Allocation	**Updated per Res G-3601**
Committed Funds for 2023	$313,091	-
Actual Incurred Cost Jan-Nov 2023	-	$236,623
Funds Needed to Complete In-Progress Projects	-	$356,605
Funds for Project Under Development for 2023	$537,359	$0
Total Sub-program Funding for 2023	$850,450	$593,228
Funds Available for Reallocation		$257,222
Sub-program Percentage of Funding	40%	29%

11.6 Residential Appliances (Retired)

11.6.1 Subprogram Overview

This subprogram develops, demonstrates, and enhances technologies and advancements related to gas-consuming appliances in residences. Subprogram staff also seek to adapt proven technologies to the California market. Relevant appliances include furnaces, hot water heaters, stoves, ovens, and dryers.

Revisions pursuant to Res. G-3601:

SoCalGas is retiring the Residential Appliances subprogram in its Revised 2023 RD&D Research Plan. Funding allocation considerations for this retired subprogram are addressed in section 11.6.6.

11.6.2 Policy Considerations

Residential Appliances projects support multiple policies and regulations:

Policy	Description
2016 Air Quality Management Plan	NOx and PM emissions regulation
CA Title 24	Buildings Energy Efficiency
CA Title 20	Appliance Energy Efficiency
AB3232	Building Decarbonization
AB32	Reduce CO_2 emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

11.6.3 2023 Key Research Areas

Based on input received during outreach activities, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Hydrogen and RNG Blends in the Home**
  Projects in this area seek to develop highly efficient residential appliances that are compatible with hydrogen and RNG blends.

11.6.4 Subprogram Benefits

Benefit	Explanation
Operational Efficiency	Increasing energy efficiency and burner performance for residential appliances also provides improved operational efficiency for customers by reducing fuel cost associated with space conditions, water heating, and cooking.
Improved Affordability	Increased energy efficiency improves cost savings and ensures that energy is affordable and equitable.
Environmental: Reduced GHG Emissions	Developing advanced appliances that are compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from residential buildings.
Environmental: Improved Air Quality	Increasing energy efficiency and burner performance for residential appliances provides an environmental benefit by reducing NOx and PM emissions.

11.6.5 Equity Considerations

The introduction of hydrogen may have higher upfront costs than conventional fuels. Therefore, high-energy-efficiency appliances in the residential space will have greater importance in ensuring that clean energy is affordable and equitable.

11.6.6 Revised Funding Table

Revisions pursuant to Res. G-3601:

Customer End-use Applications Program		
Residential Appliances Sub-program (Retired) **2023 Funding Allocation**		
	Initial Allocation	**Revised pursuant to Res G-3601**
Committed Funds for 2023	$616,599	-
Actual Incurred Cost Jan-Nov 2023		$177,022
Funds for Project Under Development for 2023	$63,760	$0
Estimated Incurred Cost Jan-Nov 2023 [(a)]		$242,750
Total Sub-program Funding for 2023	$680,359	$419,772
Funds Available for Reallocation		$260,587
Sub-program Percentage of Funding	32%	21%

[(a)]Estimate incurred costs for services rendered prior to the issuance of Res. G-3601 not yet paid and/or invoiced.

12 Appendix A: Stakeholder Input

In early 2022, SoCalGas RD&D conducted outreach to 11 organizations and spoke to 15 different individuals. Key takeaways from this year's outreach include:

1. Leverage existing infrastructure to decarbonize.
2. Hydrogen is a key technology for decarbonization.
3. Study the impact of transporting low-carbon fuels—RNG and hydrogen—and carbon dioxide in existing and new pipelines, as well as ways to retrofit existing pipelines.
4. Explore blending of hydrogen and natural gas in a natural gas power plant.
5. There is a need for more distributed hydrogen production at refueling stations.
6. Explore different ways to transport hydrogen, including liquid and ammonia.
7. Support development of dispensers, hoses, and other equipment for 10 kg/min hydrogen refueling for heavy-duty trucks.
8. Explore hydrogen production that does not consume water.
9. There is a need for more workforce development and training for students, technicians, first responders, and engineers in hydrogen and other new technologies.
10. Continue to support gas heat pump technology, particularly at greater than 100% efficiency.
11. Get ahead of regulation and police yourself using a variety of technologies and leak detection methods to reduce fugitive methane emissions.
12. Develop commercial-scale CCUS projects—including direct air capture—to prove that they can work.
13. Focus on developing data collection standards, artificial intelligence, and real-time sensors.
14. Develop protocols for low-carbon heavy-duty refueling processes.
15. Educate policy makers about safety, reliability of natural gas, hydrogen, and RNG, as well as realistic timelines for the energy transition.
16. Explore non-destructive evaluation technologies for pipelines, as well as ways to better predict and prevent corrosion.
17. Fuel cell technology needs a lot of investment.
18. Explore how to track green molecules in the pipeline and give credits.
19. Demonstrate use of gaseous fuels for heavy-duty transportation.
20. Study how to integrate gas and electric systems for resilience.
21. Support research into thermochemical conversion of woody biomass.
22. Pursue technologies with potential to reduce energy costs for ESJ communities.
23. Increase diversity through student programs.

13 Appendix B: Public Workshop Questions & Comments

B1	Submitter: Vishnu Vijayakumar, **UC Davis** (vvijayakumar@ucdavis.edu) **Q:** Are there any plans for SoCalGas to get into building hydrogen refueling stations? **A:** This question falls outside the scope of RD&D. SoCalGas' plans to develop hydrogen refueling stations are being addressed through the general rate case (GRC) process. Please refer to SoCalGas's GRC Test Year 2024 Application 22-05-015 for more information.
B2	Submitter: Paul Sandsted, **NGV America** (psandsted@ngvamerica.org) **Q:** As far as clean transportation, where RD&D is concerned, are there specific vehicle applications that your team focuses on? **A:** SoCalGas RD&D has historically focused primarily on heavy-duty on-road vehicle applications, particularly around developing and demonstrating ultra-low-NOx or near-zero-emissions compressed natural gas (CNG) heavy-duty truck engines. The focus has recently shifted toward fuel cell electric vehicles—particularly in the heavy-duty space. SoCalGas RD&D has also started exploring off-road applications, including rail, marine, and aviation. After decades of emissions reductions in the on-road sector, emissions from these off-road sectors now exceed those from on-road. Emissions reductions for off-road applications are critical to achieving decarbonization and air quality targets.
B3	Submitter: Debolina Dasgupta**, Argonne National Laboratory** (ddasgupta@anl.gov) **Q:** Can microgrid resilience be provided by CHP systems in addition to diesel? **A:** Yes, combined heat and power (CHP) systems can provide resilience like diesel backup. However, CHP systems typically operate full-time, also providing "waste heat" for heating or cooling processes—instead of only powering on for backup power. If a CHP system is sized to provide the majority of a site's power, then a customer will benefit from full/near-full energy resilience. There are also natural gas and hydrogen power generation technologies that perform similarly to diesel backup systems, only providing power when needed.
B4	Submitter: Carrie Berard, **NYSEG** (caberard@nyseg.com) **Q:** Great job Karen [McInnis]. **A:** Thank you.
B5	Submitter: Marianne Mansour, **SoCalGas** (Mmansour@socalgas.com) **Q:** Has there been research in storage of CO_2 and [the] possibility of using our underground storage facilities?

	A: SoCalGas Gas Operations RD&D does not currently have any active projects related to the underground storage of CO_2. However, projects are being developed related to carbon sequestration and storage by various research consortia. (see question B54).
B6	Submitter: Rizaldo Aldas, **California Energy Commission** (rizaldo.aldas@energy.ca.gov) **Q:** I may have missed this. Are you currently limiting your distributed generation (DG) focus on scales of below 50 kW, and, if so, what were the main drivers for that? **A:** The SoCalGas RD&D Distributed Gas subprogram is not limited in focus to sub-50kW technologies. RD&D is also interested in developing and advancing new technologies across various sizes, for a wide range of customer applications. However, RD&D included sub-50kW fuel cells as a research area due to an identified technology gap for smaller systems in the United States, and specifically California. There are several models of residential and small commercial-sized fuel cells available in Japan and Europe, with over 400,000 systems installed in Japan. RD&D staff believe that these technologies can provide several environmental and resiliency benefits in California.
B7	Submitter: Submitter: Rizaldo Aldas, **California Energy Commission** (rizaldo.aldas@energy.ca.gov) **Q:** It sounds like you've identified a gap in the product space for that size of fuel cell. So that is a focus for developing small-scale fuel cell products? Does that sound accurate? **A:** Yes, that's correct**.**
B8	Submitter: Kevin Uy, **California Energy Commission** (kevin.uy@energy.ca.gov) **Q:** Is there a projected level of RD&D funding for 2022-2023? **A:** Yes. Projected 2022 RD&D funding is discussed in the 2022 Research Plan, which was approved by the California Public Utilities Commission (CPUC) in Resolution G-3586. Projected 2023 funding is listed in Section 6.1 of this document.
B9	Submitter: Claire Becker-Castle, **SoCalGas** (cbecker-castle@socalgas.com) **Q:** The last two minutes of video were not seen on screen. **A:** We apologize for the inconvenience.
B10	Submitter: Cynthia Carter, **SoCalGas** (ccarter5@socalgas.com) **Q:** Only a comment. This is a great workshop! I'm excited for our future.

	A: Thank you.
B11	Submitter: Ludwig Lipp, **T2M Global** (llipp@t2mglobal.com) **Q:** Power for ships at the Los Angeles and Long Beach ports is a major source of pollution. SoCalGas should consider supporting fuels for clean power production for marine applications, including hydrogen. **A:** Thanks for the feedback. This is something that RD&D is interested in and will consider looking at for future projects. In fact, RD&D is currently pursuing a grant funding opportunity to provide fuel cell shore power at the ports.
B12	Submitter: Michael Slusarz, **American Gas Association** (mslusarz@aga.org) **Q:** Thank you, RD&D Team, for the great presentations. Looking forward to continuing the discussions! **A:** Thank you for participating in this public workshop.
B13	Submitter: Siari Sosa, **SoCalGas** (ssosa@socalgas.com) **Q:** Thanks all! Great presentation, very informative! **A:** Thank you for participating in this public workshop.
B14	Submitter: Bianca Tippett, **Sowing Seeds for Life** (receptionist@sowingseedsforlife.org) **Q:** This was not covered yet. How can charities better partner with the gas company to best provide services to those living food-insecure? **A:** RD&D is part of SoCalGas, a larger company that provides charitable giving programs, grant opportunities, scholarship funding, diversity and inclusion efforts, and supplier diversity. SoCalGas RD&D is happy to connect you with the correct group within SoCalGas to help facilitate those relationships. Please contact us by email at RDDInfo@socalgas.com.
B15	Submitter: Kaycee Chang, **California Energy Commission** (kaycee.chang@energy.ca.gov) **Q:** What target metrics would you be looking for around hydrogen-blended power generation? **A:** RD&D is considering several potential metrics at this time. One key metric is impact on performance, such as reduced efficiency or an increase in NOx emissions. Another key metric is impact to system durability and longevity. For example, does the hydrogen affect any components that would require shorter service intervals? Are catalysts affected? If there are any other metrics you believe that RD&D should focus on, please let us know.
B16	Submitter: Adele DiBiasio, **National Grid** (adele.dibiasio@nationalgrid.com)

	Q: Will your slide deck be available? **A:** A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B17	Submitter: Ishita Dave, **SoCalGas** (Ishah1@scgcontractor.com) **Q:** Thanks all, presenters and Matthew, for providing all this technical info through great presentations. **A:** Thank you for participating in this public workshop.
B18	Submitter: SanSan Lee, **SoCalGas** (sslee@socalgas.com) **Q:** First time attending the workshop. Excellent materials. Will take a day off to attend the workshop next year so the focus can be on the workshop only. Thank you. **A:** Thank you for participating in this public workshop.
B19	Submitter: David Blekhman**, Cal State LA** (blekhman@calstatela.edu) **Q:** Great vision. It would be great to implement small-scale fuel cells at Cal State LA for training, research, and demo projects through senior designs. Excellent job. We appreciate all the work that went into this event. Hopefully, more to come. We look forward to future collaborations. **A:** Thank you for the suggestion. We will consider this for future projects.
B20	Submitter: Zhiming Gao, **ORNL** (gaoz@ornl.gov) **Q:** How can we contact SoCalGas RD&D for a collaboration? **A:** Please contact us by email at RDDInfo@socalgas.com. Please provide a brief description of the collaboration opportunity so that SoCalGas RD&D can make sure it gets directed to the right group.
B21	Submitter: Zhiming Gao, **ORNL** (gaoz@ornl.gov) **Q:** How about NOx control in gas combustion? **A:** SoCalGas RD&D considers six distinct ratepayer benefits—such as emissions reductions, cost-savings, and operational efficiency—that help guide the direction of its research. The Gas Operations program has funded and continues to fund projects that examine NOx reduction methods through air-fuel ratio controllers, catalysts, and various other mechanisms. The Customer End-Use Applications subprogram has focused on advanced combustion burners that specifically address NOx emissions as well as the implementation

	of catalysts after treatment across residential, commercial, and industrial market segments. Lastly, SoCalGas RD&D has ramped up its research into hydrogen blending to address burner performance and combustion emissions of carbon monoxide and NOx.
B22	Submitter: Bob Coleman, **SoCalGas** (rwcoleman@socalgas.com) **Q:** I understand that the goal is to get hydrogen down to $1/kg and it is currently at $2/kg, though I could have this wrong. What are the improvements that need to take place to get from where we are to the goal? **A:** SoCalGas RD&D would like to clarify that while costs for hydrogen may be as low as $2/kg, those prices are typically for hydrogen produced from fossil gas sources and with no greenhouse gas emissions mitigation. Renewable hydrogen production costs are typically in the range of $5-$10/kg depending on the feedstock and pathway. That said, the DOE has identified several key areas in which costs must be reduced in order to achieve a renewable hydrogen cost of $1/kg. These primarily involve capital expense and operating expense reductions. SoCalGas RD&D supports projects and technology developments that aim to address multiple technological pathways to produce renewable hydrogen, including supporting projects to de-risk and advance cutting-edge technology as well as projects that help to further develop existing technologies to improve efficiency or reduce manufacturing costs. For electrolysis, the primary driver to reduce operating expenditures (OpEx) is reducing renewable electricity costs. On the capital expenditure (CapEx) side, RD&D supports projects to decrease electrolyzer module cost by identifying earth-abundant materials that can replace the expensive and scarce platinum group metal materials typically used in electrolysis. For other technological pathways, RD&D has supported projects in many research areas that aim to reduce OpEx by increasing reactor efficiencies. For example, RD&D has supported the development of advanced, modular, and scalable steam methane reforming (SMR) reactors that can convert renewable natural gas (RNG) to renewable hydrogen. RD&D has also supported the development of methane pyrolysis technologies that produce valuable carbon byproducts that help offset the cost of hydrogen produced through this method.
B23	Submitter: Peter Chen, **California Energy Commission** (peter.chen@energy.ca.gov) **Q:** Is there flexibility with reallocating funding across subprograms? **A:** Yes, two key goals of the public workshop are to share the proposed allocations across subprograms for 2023 and to obtain stakeholder feedback.
B24	Submitter: Peter Chen, **California Energy Commission** (peter.chen@energy.ca.gov)

	Q: What applications/sectors are interested in low-pressure hydrogen storage? Are there issues with scalability considering the established 350/700 bar standards for refueling on-road hydrogen fuel cell vehicles? **A:** Low-pressure hydrogen storage could reduce the weight of the storage tank on the vehicles in many different transportation applications. Low-pressure storage could also to reduce the energy requirements and reliability issues that come with high-pressure hydrogen storage. Low-pressure hydrogen storage may require new fueling standards and potentially require modification of the current fueling infrastructure, which is designed to operate at high pressure.
B25	Submitter: Emily Chow, **Public Utilities Commission** (emily.chow@cpuc.ca.gov) **Q:** Regarding the Food Service subprogram, will restaurant operators receive any grants or stipends that will help them purchase high-efficiency equipment in combination with the educational opportunities mentioned? **A:** The SoCalGas Energy Resource Center (ERC) offers seminars, demonstrations, and consulting services to help local businesses find cost-effective, energy-efficient solutions. The webpage is located at: https://www.socalgas.com/for-your-business/education-and-training/energy-resource-center. This past year, the ERC offered customers a complete virtual experience to help them select and acquire rebates for high-efficiency equipment during the pandemic. On the rebate side, SoCalGas was able to offer a 50% deemed rebate until 12/31/2021. The ERC has also been working on offering grants for restaurant workers through the California Restaurant Foundation.
B26	Submitter: Emily Chow, **Public Utilities Commission** (emily.chow@cpuc.ca.gov) **Q:** What a fantastic workshop! Is there anywhere we can sign up to receive notifications for future SoCalGas workshops like this one? **A:** All attendees of the public workshop you are automatically added to the SoCalGas RD&D email list to receive notification of future workshops and webinars. Anyone interested in signing up for notification should contact us by email at RDDInfor@socalgas.com.
B27	Submitter: Michael Allawos, **Allawos & Company** (michael.allawos@allawosandcompany.com) **Q:** Was it correct that there is over $8 billion available for the production of hydrogen for local hubs? Can you please show the slide that illustrates this? **A:** This was slide 58 in the presentation. The bipartisan infrastructure law (BIL) has allocated $8 billion in DOE funding to support at least four regional hydrogen hubs. See[https://www.energy.gov/articles/doe-establishes-bipartisan-infrastructure-laws-95-billion-clean-hydrogen-initiatives for more information.

B28	Submitter: Michael Allawos, **Allawos & Company** (michael.allawos@allawosandcompany.com) **Q:** Would SoCalGas be interested in a partnership with San Bernardino International Airport to go after the $8 billion for a proposed hydrogen production facility to provide hydrogen for aircraft? **A:** The hydrogen hubs funding opportunity is primarily being handled outside of RD&D. SoCalGas RD&D will pass along the information to the team that is looking at proposed hydrogen hub activities.
B29	Submitter: Sean Anayah, **California Energy Commission** (sean.anayah@energy.ca.gov) **Q:** Public Utilities Code (PUC) 740.1(d) states that projects should not unnecessarily duplicate research undertaken by other organizations. How does SoCalGas ensure non-duplicity? Thanks. **A:** One of the one of the key ways SoCalGas RD&D strives to eliminate non-duplicity is by working through research consortia that will be described in more detail later in the public workshop. Research consortia tend to be organizations composed of multiple research entities and utilities across the United States and even North America. If, for example, a utility on the East Coast is conducting similar research, SoCalGas RD&D would be aware of it through working with them through its consortia efforts. In working with these research consortia, SoCalGas RD&D has the opportunity to leverage funding by pooling and coordinating funding from multiple resources. Other ways SoCalGas RD&D strives for non-duplicity are through review by subject matter experts on staff, workshops, connecting with the research community, attending conferences, and generally developing its network of researchers from across the United States and around the world. These efforts help SoCalGas RD&D stay up to date on the current state of the art and conduct research that advances technology without duplicating work that's already been done.
B30	Submitter: Sean Anayah, **California Energy Commission** (sean.anayah@energy.ca.gov) **Q:** Has the utilities' obligation to serve (CPUC 451) been considered as electrification replaces gas services? **A:** This question falls outside the scope of RD&D.
B31	Submitter: Sean Anayah, **California Energy Commission** (sean.anayah@energy.ca.gov) **Q:** How does SoCalGas propose to alleviate the burden to commercial food services, industry, and residents with future required installations of high-efficiency technologies?

	A: Generally speaking, SoCalGas could help alleviate the burden by improving or increasing the incentives to help reduce customer costs. SoCalGas can also help in this space by providing education on the type of technology available to the customer base. One of the major problems associated with the turnover to high-efficiency equipment is that not a lot of restaurant operators are aware that the technology exists. Thus, education and outreach will be a great resource to help address this concern. Two examples of such programs outside of SoCalGas RD&D are the customer programs that develop incentives for high-efficiency equipment and the Energy Resource Center, which includes a demonstration kitchen where customers can test out new, high-efficiency equipment and learn more about it.
B32	Submitter: Charles Sponberg, **SoCalGas** (csponberg@socalgas.com) **Q:** Are there any micro projects that would digest home food and yard clippings into methane that could then make power? **A:** SoCalGas RD&D has engaged with Cal State University, Los Angeles on its senior design projects over the past few years. One of the senior design projects involved operation of a Home Biogas Unit, a small anaerobic digester designed to fit into a residential backyard. The methane produced could then be used to operate a small cooking device. More information about this project is available on page 36 of the SoCalGas RD&D 2019 Annual Report.
B33	Submitter: Charles Sponberg, **SoCalGas** (csponberg@socalgas.com) **Q:** What is the longevity and reliability outlook for the fuel cells in use and for lower-cost future fuel cells? **A:** The fuel cells that SoCalGas RD&D is looking into have a claimed longevity of five to ten years, depending on the fuel cell technology and manufacturer. In most cases, the systems have much longer lifespans, only requiring the fuel cell stack (catalyst) to be replaced at the five-to-ten-year mark. Assessing degradation in power output is one of the goals for RD&D lab and field evaluations of new technologies. In addition, some of the systems require minimal maintenance, such as filter replacements. As for the reduction in fuel cell cost, this is something RD&D hopes to achieve through its projects—both directly through foundational research into new fuel cell technologies and indirectly through demonstrating the benefits, providing a pathway to scaled production.
B34	Submitter: Charles Sponberg, **SoCalGas** (csponberg@socalgas.com) **Q:** I may have missed it, but will this presentation be available for viewing again?

	A: A recording of the full workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B35	Submitter: David Xu, **PG&E** (dxx2@pge.com) **Q:** How does your company conduct deployment of the completed R&D projects? **A:** If the technology reaches commercialization, one pathway is to use the technology internally for potential deployment in SoCalGas operations. For other technologies and products, SoCalGas RD&D seeks to identify a good commercialization pathway for those technologies. Such pathways may include a commercialization partner to help a startup company or a technology provider to bring that technology to market. SoCalGas RD&D then works to advance that technology into the commercial space so that it can provide benefit to SoCalGas customers.
B36	Submitter: David Xu, **PG&E** (dxx2@pge.com) **Q:** How is your upper management's support of the R&D [projects]? [Have there been] budget increases or decreases in recent years? **A:** The SoCalGas RD&D program and the annual budget are authorized by the CPUC via the General Rate Case process. Budget allocations outlined in the Research Plan are submitted to the CPUC via a Tier 3 Advice Letter and approved annually by Resolution.
B37	Submitter: David Xu, **PG&E** (dxx2@pge.com) **Q:** Can the current infrastructure handle the hydrogen? If so, what [is] the supporting evidence? If not, what is the viable plan and the associated cost estimation? **A:** Research is being conducted to perform due diligence on all portions of the existing gas infrastructure to determine the effect of various blends of hydrogen. The status of existing projects can be found in the 2021 RD&D Annual Report, Appendix *2021 Summary of Ongoing and Completed Projects*. Since research is ongoing, publications are pending.
B38	Submitter: Arezoo Khodayari, **California State University, Los Angeles** (akhoday@calstatela.edu) **Q:** Thank you for the great update. What is the plan to sustain the collaboration and partnerships that you have established with your current university partners? **A:** Part of the workshop outreach effort is to engage with current SoCalGas RD&D research partners as well as new research stakeholders to help identify new technologies and research areas. RD&D looks forward to continuing to

	have those discussions with its current and potential research partners to refine the research program and the plan for 2023.
B39	Submitter: Arezoo Khodayari, **California State University, Los Angeles** (akhoday@calstatela.edu) **Q:** Will there be an update later today about the status of the hydrogen blending with natural gas and its prospects? **A:** Today's presentation won't cover any specific projects in great detail, as there is a lot to cover in the 2023 Research Plan, but please feel free to e-mail rddinfo@socalgas.com with a specific question.
B40	Submitter: Arezoo Khodayari, **California State University, Los Angeles** (akhoday@calstatela.edu) **Q:** How can we see the list of participants here on the dashboard? Also, how can we change the name that appears on the screen? **A:** Our workshop platform does not have the functionality to show all attendees during the broadcast. For a list of organizations represented at the workshop, please refer to section 3.2 of this document.
B41	Submitter: Norman Pedersen, **Southern California Generation Coalition** (npedersen@hanmor.com) **Q:** Where will you post the workshop feedback questions and other handouts on the SoCalGas website? See the Public Workshop Notice. **A:** A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd. The workshop feedback questions are included in this document in Appendix B and C.
B42	Submitter: Norman Pedersen, **Southern California Generation Coalition** (npedersen@hanmor.com) **Q:** Where will you post the slide deck on the website? **A:** A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B43	Submitter: Norman Pedersen, **Southern California Generation Coalition** (npedersen@hanmor.com) **Q:** In your feedback question #2 about power generation, are you talking about fueling the power generation with blended fuel or fueling with 100% hydrogen? If the latter, how would you separate the hydrogen from the blended gas flow?

	A: For question #2, we are specifically talking about hydrogen blended fuel. However, we are also interested in achieving 100% hydrogen utilization in some cases. The ultimate goal would be for the customer to receive hydrogen (blended or pure), and for their equipment to be compatible the fuel composition received. **Q:** In the case of 100% hydrogen, how would the hydrogen be separated from the blended gas flow? Is the question: "In the future if there was a supply of 100% hydrogen, could we enable the power generation to be fueled along that supply?" **A:** Ideally, when hydrogen is delivered to the customer, whether 100% hydrogen or blended with natural gas, the customer's equipment would function normally without the need to separate the hydrogen. If the hydrogen needed to be separated from the natural gas for a specific use case, there are technologies that can facilitate this, such as the HyET hydrogen separation technology highlighted on Page 23 of the 2021 RD&D Annual Report.
B44	Submitter: Julieta Lafond, **Sempra** (JLafond@semprautilities.com) **Q:** Will you be describing more on what type of projects are part of the allocations, e.g., Low Carbon Resources, Customer End-Use Applications? **A:** Yes. The workshop presentation includes deep dives into each of the five programs within RD&D. The presentations describe what each program focuses on and what research areas have been identified for 2023. A recording of the workshop is available on the SoCalGas RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B45	Submitter: Julieta Lafond, **Sempra** (JLafond@semprautilities.com) **Q:** Will there be collaborations with disposal companies to enable users and communities to donate their organic waste? **A:** Thank you for the suggestion. This type of strategy will likely be required to enable RNG at scale. In some municipalities, organic waste is already going to an anaerobic digester to make renewable natural gas, which then fuels the waste hauler's fleet. For example, CR&R Environmental is injecting renewable natural gas produced at CR&R's anaerobic digestion facility in Perris, California, into the SoCalGas pipeline. For more information, visit the SoCalGas website: https://www.socalgas.com/sustainability/renewable-gas/rng-success-stories/crr-environmental.
B46	Submitter: Lorna Holt, **SoCalGas** (lmholt@socalgas.com) **Q:** You showed a list of benefits. Is there a particular benchmark used for the overall benefits? **A:** Thank you for the question. SoCalGas RD&D has a rigorous project selection process. The projects are first vetted and the benefits to SoCalGas ratepayers

	identified. Then, RD&D staff conduct an internal review for funding approval before the project moves forward.
B47	Submitter: Lorna Holt, **SoCalGas** (lmholt@socalgas.com) **Q:** Do you know when other workshops will be held? Are they quarterly? **A:** SoCalGas RD&D holds a public workshop once a year to help prepare the following year's research plan. In addition, SoCalGas RD&D holds quarterly research webinars where RD&D staff and project research partners share details of projects that are active or have been recently completed. Recordings of past webinars and information about upcoming webinars can be found on the RD&D website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd.
B48	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** How and to what extent does SoCalGas coordinate its research projects with the Gas Research Institute? **A:** The Gas Research Institute (GRI) merged with Institute of Gas Technology (IGT) to become the GTI Energy in 2000. SoCalGas RD&D has maintained a close and long-standing relationship with GTI Energy and its predecessors. SoCalGas RD&D also coordinates a number of research projects through consortia. GTI Energy is an important part of the ecosystem for generating new projects, coordinating new research teams, and applying to funding solicitations. GTI Energy administers both the Operations Technology Development and Utilization Technology Development consortia.
B49	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Does the research program include analyses of alternatives to underground storage fields such as Aliso Canyon? Has SoCalGas studied means of making these underground storage fields less prone to explosions or methane releases? **A:** Currently, SoCalGas RD&D is not funding research in alternatives to underground storage fields. The SB1371 Leakage Abatement RD&D Program has funded research to detect, quantify, and minimize methane emissions at SoCalGas facilities including underground storage fields. For more information, see https://www.socalgas.com/regulatory/R1501008.
B50	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Has SoCalGas conducted research on preventing large-scale transmission lines from failures in the desert area? **A:** Yes. SoCalGas has conducted research supporting pipeline integrity, including improving inspection technologies such as inline inspection (ILI) tools to detect corrosion and mechanical damage through the research consortia Pipeline Research Council International and NYSEARCH. The status of existing

	projects can be found in the 2021 RD&D Annual Report, Appendix *2021 Summary of Ongoing and Completed Projects*.
B51	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Doesn't renewable natural gas create GHG emissions when it is burned by the end user? What are the net GHG emissions when RNG is used by regular end users? **A:** Burning natural gas, whether renewable natural gas (RNG) or fossil-sourced natural gas, produces GHG emissions at the point source. However, from a perspective of net GHG emissions and net carbon intensity, RNG results in reduced GHG emissions and lower carbon intensity compared to fossil-sourced natural gas. In many cases, RNG can demonstrate net-zero or net-negative carbon intensities. Please see the California Air Resources Board's (CARB) most recent GREET modeling outputs demonstrating negative carbon intensities of RNG, particularly when used as a transportation fuel, at https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation. For context, the feedstock that is used as an input to produce RNG is primarily diverted from waste streams—including dairy manure, forestry residues, organic food waste, and other biomass—that would otherwise emit large quantities of methane. Methane has a much higher carbon intensity than CO_2. By diverting those feedstocks to produce fuels such as RNG, those methane emissions are reduced or eliminated. Additionally, the RNG that is produced can displace demand for fossil-sourced natural gas, resulting in further emissions reductions and increased environmental benefits.
B52	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** How much RNG is potentially available to supply California natural gas users? Could as much as 50% of supply come from RNG sources? **A:** A recent CARB inventory report on GHG emissions has demonstrated that as much as 7% of California's GHG emissions comes from agricultural and forestry activities. Much of these can be diverted to produce RNG. The California legislature has passed several bills regarding expanding RNG development or procurement. For example, SB 1383 involved reduction of biogenic methane emissions and resulted in the development of large-scale anaerobic digestion as a means to divert waste streams to produce RNG. As a result of SB 1440, California will explore managing its woody biomass resources and waste forestry and agricultural residues through gasification or pyrolysis to produce biomethane, deliver RNG, and reduce short-lived climate pollutant emissions.

	SoCalGas is seeking to increase the proportion of RNG in the natural gas it delivers to its customers. Currently, SoCalGas' goal is for RNG to make up 20% of all natural gas it delivers by 2030.
B53	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Does the production of RNG produce toxic chemicals or other waste products that must be disposed of safely? **A:** There are multiple pathways—including biomethanation, anaerobic digestion, and gasification—that can produce RNG. In addition, multiple feedstocks can be used as inputs in these pathways. However, RNG is most often produced from biogas sources, such as the anaerobic digestion of animal and food waste, landfills, and wastewater treatment facilities. These biogas sources produce roughly a 60:40 mixture of methane and carbon dioxide, respectively, that is separated using gas separation technologies such as membranes, amine scrub, and pressure swing adsorption. Other ways to produce RNG are the conversion of carbon dioxide using hydrogen in biomethanation or thermochemical process that produce nearly pure methane. In general, production of RNG does not, by necessity, result in toxic chemicals that need to be managed, stored, or disposed of. During certain processes using specific feedstocks, some toxic compounds can be produced temporarily and often in small quantities, usually at parts-per-million (ppm) levels; these are usually destroyed, converted, or neutralized in later steps of processing. Regarding biogas sources, hydrogen sulfide is produced naturally along with carbon dioxide and methane during the decomposition of our waste streams and ranges from 50 to 5,000 ppm by volume but can reach up to 20,000 in some cases. Hydrogen sulfide is easily removed from renewable and fossil natural gas using well established technologies that are common in the oil and gas industry. In addition to hydrogen sulfide, siloxanes can be produced from landfills and may be present in landfill gas. Tars can be formed during the first stage of gasification if it is conducted at low temperatures. SoCalGas does not allow any toxic content, from RNG or otherwise, into its gas grid.
B54	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Right, and has there been research in storage of CO_2, and possibly using SoCalGas underground storage facilities? **A:** SoCalGas RD&D has not supported any efforts to store CO2 at any SoCalGas' underground storage sites, however, SoCalGas RD&D have participated in a CO2 injection and storage study in the central valley with Clean Energy Systems (CES) that was completed and presented in SoCalGas' RD&D 2019 Annual

	Report. RD&D staff are open to evaluating potential research projects in this area involving geologic or other long-term sequestration. SoCalGas RD&D has supported several projects looking at utilizing CO_2 to produce fuels or durable products, such as building materials or plastics.
B55	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** The San Bruno explosion happened in part because of a power failure at a PG&E compressor station. When the power came back on, there was a surge of pressure that may have triggered the explosion. Is SoCalGas conducting research on how to prevent this type of incident in its transmission system? **A:** The San Bruno incident occurred in 2010. Much has transpired since then to address the issues involved. SoCalGas has pressure control systems in place to trip and prevent system over-pressurization. Basic Process Control Systems and Safety Systems are designed to have redundant sources of power supply.
B56	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Why has the repair on Line 400 taken so long and what can be done to speed up the restoration process? **A:** This question falls outside the scope of the SoCalGas RD&D Program.
B57	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Has SoCalGas explored the use of treated effluent water as a source of water for hydrogen electrolysis? **A:** Our understanding is that treated effluent water can always be further treated to reach purity levels required for existing electrolyzer technology. SoCalGas RD&D has not yet been involved in any projects that have explored directly electrolyzing low-purity water, such as brackish or effluent water.
B58	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Does SoCalGas anticipate delivering hydrogen to fueling stations via pipeline or via trucks? **A:** RD&D is investigating several avenues for supplying fueling stations with hydrogen, including separating hydrogen from a blend of gases delivered by pipeline[45] and modular electrolyzers for distributed hydrogen production.[46]
B59	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Are there any active research programs regarding using hydrogen in maritime settings?

[45] Renewal: SoCalGas RD&D 2021 Annual Report, p.23
[46] Renewal: SoCalGas RD&D 2021 Annual Report, p. 78

	A: There are currently two such active projects. To learn more, see the SoCalGas RD&D 2021 Annual Report on pages 167 and 168. The relevant project titles are "CALSTART Hydrogen Zero Emission Tugboat Design" and "GGZEM Harbor Craft Demonstration." Both projects received H2RAM funding from the CEC.
B60	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Is EPRI doing comparable research on fuel cell backup power applications? Is SoCalGas coordinating with their efforts? **A:** We are not aware of any active EPRI fuel cell projects at this time. However, they have conducted such projects in the past and are interested in the technology. We regularly coordinate and participate in projects directly with EPRI. We also participate in the Low Carbon Resources Initiative, which EPRI co-manages.
B61	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Fuel cells have been available for many years, but they seem to be like nuclear fusion projects, too many years in the future to be practical. Have fuel cell costs declined in recent years and is lowering their costs a focus of your research? **A:** There has been a steady decrease in fuel cell prices over the past decade in Japan, where the ENE-FARM program has deployed over 400,000 fuel cells to residential customers. This is a result of technology advancements and market scale. This type of price reduction is something that RD&D is interested in achieving in California. RD&D is interested in directly reducing costs through fundamental research as well as demonstrating the benefits of fuel cells in the field so they can achieve widespread adoption.
B62	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Do fuel cells require the use of expensive imported rare earth elements or other hard-to-obtain materials? **A:** This is dependent on the fuel cell technology, as well as the manufacturer. Each system is a little different; some technologies do not require precious metals. Developing technologies that reduce the use of these materials is of interest to SoCalGas RD&D.
B63	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Is the CAISO supportive of the increased use of fuel cells on the grid? Are fuel cells forecast to be an important source of generation over the next 20 years? **A:** The RD&D team can't speak to this, but SoCalGas does have policy teams dedicated to working with CAISO and other regulators to address this question.
B64	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com)

	Q: For industrial and commercial applications, will customers have to replace existing end-use devices—boilers, fryers, etc.—to use hydrogen as a fuel source instead of natural gas? **A:** The Customer End-Use Applications subprogram is actively working with researchers and original equipment manufacturers to develop solutions that enable the SoCalGas customer base to retrofit its existing end-use devices to use blends of hydrogen. It remains to be seen how this will play out in the long term, when pure hydrogen might be the main fuel source, but it is a topic that SoCalGas RD&D is exploring.
B65	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** What type of safety issues does the use of hydrogen present to end users and the existing pipeline systems? It is my understanding that pure hydrogen can degrade existing pipelines and I would anticipate end-use equipment as well. **A:** There are potential safety concerns regarding burner flashback that SoCalGas RD&D is currently exploring, but preliminary research suggests that at low blends of hydrogen (0-30%), flashback is typically not a concern and there are no major safety hurdles at the lower blends. As far as the higher blends are concerned, flashback could be a part of SoCalGas RD&D research. RD&D staff are currently exploring design improvements to reduce any possible safety issues. Gas Operations RD&D is currently funding research to identify any potential safety considerations or gaps that need to be addressed with the addition of hydrogen blends to the natural gas infrastructure. The status of existing projects can be found in the SoCalGas RD&D 2021 Annual Report, Appendix 2021 *Summary of Ongoing and Completed Projects*.
B66	Submitter: Jason Zeller, **UCAN** (Jazzell2@yahoo.com) **Q:** Is SoCalGas looking into using fuel cells as a source of battery-type storage for use when renewable generation declines in the late afternoon/evening? **A:** This is one of the use cases that SoCalGas RD&D is interested in researching and demonstrating around fuel cells. Hydrogen could be generated from renewable energy during the day via electrolysis, stored, and then used to fuel a fuel cell to produce power. This could be done at the microgrid level behind the meter or at grid scale. In addition to reducing emissions in the evening, hydrogen storage and fuel cells help improve energy resilience.

14 Appendix C: Post-Workshop Stakeholder Input

<table>
<tr><td>C1</td><td>Submitter: Ron Chong, Road Runner (ron.chong@roadrunner.com)

Q: Thanks for the opportunity to participate in the Public Workshop last Wednesday. It was interesting to see the wide variety of projects past and present. Maybe you could share some of these projects to business and residential users, especially those which will be beneficial by lowing their carbon footprint and utility bills. A handout could be inserted into the utility bills, maybe quarterly and/or promoted online. A few comments on hydrogen blending. Hydrogen's energy content is lower than methane on a volume basis and this will lower the heating value supplied to consumers. What does that do to the amount of gas that is combusted? How much more gas has to be consumed for cooking and heating? Does it raise the price for the consumer?

A: You are correct when you say hydrogen contains less energy, by volume, than natural gas. Since hydrogen is less dense than natural gas, however, a gas blend flows faster than pure natural gas. Thus, for many residential appliances, a greater volume is delivered and combusted to produce the same amount of heat. Notably, this isn't true for all applications. At low hydrogen blend ratios, the lower energy content is approximately canceled out by the higher flow rate, and the overall amount of heat delivered is similar. At higher blend ratios, though, the gas eventually reaches a maximum flow rate and the amount of heat delivered also reaches a maximum value. At some ratio, this maximum heat value becomes increasingly less by volume than that of pure natural gas. The higher flow rate does not necessarily cause the bill to increase, however, because SoCalGas charges by energy content, not by volume. Some combustion effects, like flame size, may affect heat efficiency and thus energy usage.</td></tr>
<tr><td>C2</td><td>Submitter: Ron Chong, Road Runner (ron.chong@roadrunner.com)

Q: Hydrogen is known to cause embrittlement in some metal at certain pressures and temperatures. In the refinery, hydrogen attacks stainless steel and causes it to crack. Will it affect the burner material on our cooktops similarly?

A: Cooktops operate at relatively low pressures, so embrittlement is not expected to be as problematic as it can be in high-pressure cylinders and pipes. Due to the proximity of the hydrogen flame, though, the cooktop burner may grow too hot, which could affect durability. The SoCalGas RD&D team is actively planning to look into this.</td></tr>
<tr><td>C3</td><td>Submitter: Ron Chong, Road Runner (ron.chong@roadrunner.com)

Q: SoCalGas injects mercaptan (sulfur) to odorize methane gas for safety. Will the addition of hydrogen in natural gas result in a reaction of the hydrogen with the sulfur to form hydrogen sulfide (H2S)? If there is any moisture present in the natural gas, it may form an acid solution and cause</td></tr>
</table>

	corrosion because the pipes to deliver natural gas to homes are galvanized steel pipes. What are the safety issues in using high hydrogen content in the natural gas delivered to residences? **A:** The SoCalGas RD&D team does not expect sulfur compounds to react with hydrogen at room temperature in the distribution system, but it could be different in power plants. Sulfur compounds could form sulfur dioxide (SO_2) upon combustion and would then be converted to sulfite (SO_3) on a Selective Catalyst Reduction (SCR) catalyst. The RD&D team is actively evaluating the effect of hydrogen blends on SCR catalyst performance in the presence of SO_2. Downstream of the SCR unit at lower temperatures, SO_3 would react with water vapor to form sulfuric acid which would likely cause corrosion issues.
C4	Submitter: Rick Brown, **Aspen** (rick.brown.138@gmail.com) **Q:** Can you send a link to the location of the webinar PowerPoint presentation? **A:** A recording of the workshop is available on our website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd. Look for the section labeled "Public Workshop Notice" and follow the link marked "View Recording."
C5	Submitter: Vicki Shattuck, **Spire Energy** (vicki.shattuck@spireenergy.com) **Q:** I was able to attend the webinar yesterday and had thought I downloaded the deck but am unable to find it now. Can you give me access to the presentation from yesterday? **A:** A recording of the workshop is available on our website: https://www.socalgas.com/sustainability/research-development-demonstration-rdd. Look for the section labeled "Public Workshop Notice" and follow the link marked "View Recording."
C6	Submitter: Bianca Tippett, **Sowing Seeds for Life** (receptionist@sowingseedsforlife.org) **Q:** It was nice to listen in on the webinar. I will tell you right now I had no idea that SoCalGas Company has so many projects each year to help save energy. Your beginning spokesman Mathew Gregori was very well spoken and knew what he was talking about. I did have a couple questions. First, in what ways can we, at home, try to save on energy? Are there certain windows we should have or particular types of appliances? Second, what type of scholarship funding do you provide? **A:** Please visit our "Ways to Save" webpage:

	https://www.socalgas.com/save-money-and-energy/energy-saving-tips-tools/ways-to-save. You can complete your Energy Profile and get a household energy analysis and customized energy-efficiency recommendations. You can also build a personalized Savings Plan to help you keep track of your energy-efficiency progress and ultimately help lower your bills. Please, also, visit the Scholarship Program webpage: https://learnmore.scholarsapply.org/socalgas/ SoCalGas has established a scholarship program to assist current high school seniors in select Southern California counties who plan to continue their education in college pursuing a STEM, finance, or accounting field of study. The program is administered by Scholarship America®, the nation's largest designer and manager of scholarship, tuition assistance, and other education support programs for corporations, foundations, associations, and individuals.
C7	Submitter: Bianca Diaz-Hladek, **Mar Vista Family Center** (bdiaz@marvistafc.org) **Q:** It's really great that SoCalGas is working to provide a better environment using natural gas. I especially appreciate the effort in reaching out to all communities through partnerships with universities and non-profits that SoCalGas can support with ensuring that underrepresented communities are included. I would like to learn more about how we can support these efforts through providing education to families in our community. Are there or will there be workshops that our staff can attend to implement this in our programming? I believe that getting people in our community to make environmental issues a priority is a great challenge for different reasons, one being the fear of higher prices. What is the best way for non-profits, that work directly with the community, to support these efforts in partnership with SoCalGas? Thank you so much for the opportunity to participate in the webinar and become informed of the RD&D Program. **A:** All attendees of the public workshop are automatically added to the RD&D email list to receive notification of future workshops and webinars. Anyone interested in signing up for notification should contact us by email at RDDInfor@socalgas.com.
C8	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** I recently read an article in the Los Angeles Times about the effects that heavy truck traffic coming to and from the Ports of Long Beach and Los Angeles are having on a low-income area of Wilmington. I believe that hydrogen-fueled trucks and locomotives could substantially (if not largely) eliminate much of the particulate and nitrous oxide pollution associated

	with heavy freight hauling operations near the port. Because many of the vehicles and locomotives involved are part of larger corporate fleets, it makes sense to focus on converting these vehicles to hydrogen and/or batteries as a first step towards decarbonizing transportation. I urge SoCalGas to pursue research initiatives in this area. **A:** The emissions from heavy-duty trucks traveling to and from the ports are a significant contributor to local air pollution. As you noted, this pollution often affects many disadvantaged communities located near the ports and along inter- and intra-state trucking corridors. SoCalGas RD&D currently has several active projects focused on heavy-duty trucking. Examples can be seen on pages 172-178 of the 2021 RD&D Annual Report. In addition, RD&D plans to allocate 30% of the 2023 Clean Transportation budget to On-Road projects, which focus on developing and demonstrating zero-emission vehicles to help address this critical issue, while simultaneously meeting the technical needs of fleet operators.
C9	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** The increased use of renewable generation in California and adjacent states has created a mismatch between peak power generation periods and times of peak demand, which typically arise after renewable generation declines. I urge SoCalGas to develop an RD&D project that would use excess renewable generation (in California) to power electrolysis of water to produce hydrogen that could be used in adjacent fuel cells to serve as a backup power source similar to battery storage. Rather than sending excess generation out of state, this excess generation could be used to create "green" hydrogen that could in turn power fuel cells as surrogate batteries. I recognize that SoCalGas's research program and budgets have already been set for 2022/2023, but I urge you to explore this option in your future research endeavors. **A:** We agree that the current dynamic with renewable energy production and customer energy use provides a good opportunity for hydrogen and fuel cells. This is an area RD&D is exploring developing more projects around. SoCalGas RD&D currently has two active projects with UC Irvine that seek to address this issue: “UCI Hydrogen Enabled Microgrids for Critical Infrastructure Research” and “UCI Hydrogen Energy Storage and Integration with Dispatchable Power Generator System Design.” The latter of these is co-funded by the DOE. RD&D is also in the process of finalizing the contract on another related DOE-co-funded project with the National Renewable Energy Laboratory and GKN Hydrogen.
C10	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** I'm curious about the relative efficiencies of natural gas heat pumps versus electric heat pumps. Has SoCalGas (or someone else) examined the overall carbon footprints of these two technologies? **A:** For residential applications, GTI Energy published a study last year that compared a gas heat pump (GHP)-based combi system (furnace/water heater replacement) to alternatives, including electric heat pump options, using experimentally calibrated building energy models. The primary

	takeaway was that for the climate zones modeled, the GHP option provides the least-cost and lowest-GHG-emission approach for the current grid mix. This publication can be found at: https://docs.lib.purdue.edu/ihpbc/354/.
C11	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** It is my understanding that carbon capture and storage is an expensive technology and that the prospect of future leaks of the stored gas is a continuing concern. Has SoCalGas explored the possible commercial use of stored carbon dioxide? **A:** SoCalGas RD&D has worked with commercialization partners to help develop technology that can utilize CO_2 by conversion to durable goods like building materials and plastics or to fuels. RD&D has also supported projects to upgrade biogas by conversion of CO_2, through biomethanation, to RNG.
C12	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** Has SoCalGas or GTI, or any other group looked into whether there are inexpensive or low-tech means of modifying existing gas transmission and distribution pipelines to carry hydrogen? **A:** Currently, the focus of research has been on identifying the impact of introducing natural gas hydrogen blends into the existing infrastructure and determining any gaps in research. Research is being conducted in a variety of areas by several research organizations to provide the necessary technical basis for implementing hydrogen blends. The status of existing projects can be found in the SoCalGas RD&D 2021 Annual Report, Appendix *2021 Summary of Ongoing and Completed Projects*.
C13	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** Given the on-going challenges associated with the Aliso Canyon Underground Storage Field, has SoCalGas considered conducting some research on alternatives to the continued use of this facility? **A:** This question falls outside the scope of the SoCalGas RD&D Program.
C14	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** I urge SoCalGas to reach out to its suppliers in the Permian Basin and the San Juan Basin to use infrared sensors (or other devices) to survey sources of methane leaks both in production areas and along El Paso, Transwestern, and Kern River's pipelines. Methane is a far more potent global warming catalyst than carbon dioxide alone and efforts to control methane leaks need to be a priority. **A:** This question falls outside the scope of the SoCalGas RD&D Program.
C15	Submitter: Jason Zeller, **UCAN** (jazzell2@yahoo.com) **Q:** Many low-income communities in Southern California are bisected by freeways and/or industrial/warehouse facilities that have substantial

	negative localized health effects on affected communities. I urge SoCalGas to reach out to its network of community-based organizations to develop local RD&D projects in these areas that will reduce GHG emissions and improve local air quality. For example, retrofitting a backup diesel generator at a local hospital with a fuel cell. **A:** Working with community-based organizations (CBOs) to develop projects that benefit our local communities is of great interest to SoCalGas RD&D. Thank you for the project suggestion.
C16	Submitter: Peggi Hazlett, **Greater Ontario Business Council** (phazlett@ontario.org) **Q:** Thank you so much for such an informative workshop recapping the past year's RD&D projects and programs for SoCalGas. I really appreciate the connection with local universities and the emerging workforce. Strategically placing these projects on campuses brings an exposure to the next generation of research employees. As I stated in my question, partnering with institutions of higher education in the Inland Empire could be a win-win for everyone! With so many challenges facing the logistics and distribution industries, the emergence of alternative fueled trucks is key. Decarbonization of GHG emissions by replacing older vehicles that are impacting our region with hydrogen cell vehicles along with electric-powered fleets needs to be in the forethought of policy makers. I found the handouts to be particularly helpful and easy to read. Thank you for that!! If there is anything that we can do at the Greater Ontario Business Council to assist SoCalGas, please let me know. **A:** Thank you for your comments and your participation in our Public Workshop.

15 Appendix D: Project Selection Process

When identifying promising projects and evaluating them for potential funding, RD&D Program staff take a comprehensive yet flexible approach that enables them to 1) identify potential projects most in alignment with RD&D Program goals, state and federal environmental policy, and industry demand; 2) accurately assess the likelihood of potential projects to succeed; 3) work with proven partners and technologies over time; and 4) respond nimbly to changing market, technology, and policy drivers. In addition—remembering that some technologies will not result in concrete benefits until implemented at scale—RD&D Program staff consider the overall development and implementation process and research life cycle of a given technology or product.

RD&D Program area staff explore a variety of avenues to identify and conceive potential projects, including:

Table 7: RD&D Program area staff explore many avenues to identify and conceive potential projects.

Addressing Internal Operations Needs	RD&D Program staff address the needs of SoCalGas operations through regular engagement with a large number of SMEs within the organization. These SMEs provide input into technology development strategies, review research proposals, and participate in RD&D Program projects by providing technical input and guidance. They also serve as the internal technical leaders in regulatory proceedings, provide awareness of industry activities, and help manage internal policies and procedures.
Addressing Customer Needs	SoCalGas Account Executives work closely with commercial and industrial customers. The Customer Strategy & Engagement group interacts with residential customers through programs such the Customer Insight Panel. These teams often bring customer challenges to RD&D Program staff, seeking to identify available products or technologies to address a need, or, if none exists, to spur research aimed at advancing or developing appropriate new technologies or products.
Literature Surveys, Conferences, and Workshops	RD&D Program staff engage in ongoing education in their areas of expertise to remain abreast of the latest technologies and research and also scout potential opportunities. They regularly read technical journals, visit national laboratories, and attend clean technology forums/webinars held by various DOE divisions, such as the Advanced Research Projects Agency-Energy (ARPA-E), Energy Efficiency and Renewable Energy (EERE), and the Office of Fossil Energy's National Energy Technology Laboratory (NETL). These activities enable them to identify the latest technology developments in their respective fields as soon as they are made available and perform detailed gap analyses to better understand which research areas merit further study and evaluation.

Research Consortia	RD&D Program staff leverage the national and international experience of other utilities through participation in industry research consortia, such as Utilization Technology Development (UTD), Operations Technology Development (OTD), NYSEARCH, and Pipeline Research Council International (PRCI). Close relationships with these organizations facilitate the generation of project ideas, development of proposals based on business value and SoCalGas ratepayer needs, enable SoCalGas to vet potential projects with industry counterparts~~real-world end-users~~, and provide access to significant amounts of co-funding.
External Funding Opportunities	When public agencies, such as the CEC or the DOE, release a funding opportunity, RD&D Program staff often receive proposals from third-party researchers or entrepreneurs applying to the opportunity with a request for a letter of support and/or cost share from SoCalGas. Additionally, RD&D Program staff continually track various governmental funding opportunities and leverage their existing relationships with researchers and entrepreneurs to assemble teams, develop proposals, and submit applications when funding opportunities are identified.
Proposals from Researchers	RD&D Program staff have developed a strong network of researchers throughout North America. These researchers serve as a rich source of project concepts for RD&D Program staff, who often work with the researchers to refine and improve concepts of interest and identify relevant co-funding opportunities, project demonstration sites, or strategic partners that can enhance the quality of the project and maximize potential customer benefit.
Technology Roadmap Development	RD&D Program staff often engage groups of SMEs to identify scientific and technological gaps as well as promising technology pathways in each program area. After identifying the gaps and pathways, the team recommends promising technologies that are close to demonstration or commercialization and others that are earlier in the development cycle but are likely to result in significant long-term benefits. Staff then develop a detailed long-term plan to address the gaps and demonstrate the feasibility of a selected technological pathway.
Public Workshops and Outreach	The annual RD&D Stakeholder Workshop provides a forum for many stakeholders—including private, governmental, and academic researchers, regulatory and policy staff, entrepreneurs, businesses, equity and environmental justice advocates, community-based organizations (CBOs), and the general public—to offer guidance, discuss research needs, and describe project ideas to RD&D Program staff. SoCalGas also conducts pre- and post-workshop outreach to interested stakeholders to enable longer, more thoughtful discussion about RD&D topics. RD&D Program staff also participate in panel discussions and conferences where stakeholders present project proposals or where education and engagement opportunities exist.

Policy Drivers	SoCalGas strives to align the RD&D Program with California's policy goals, including building and transportation decarbonization. RD&D Program staff leverage a network of relationships with experts at local, state, and federal agencies to track current and potential future policies and regulations in order to identify and develop project concepts to achieve these goals.

Although staff from each of the five program areas have distinct research interests, goals, and industry relationships, all follow a similar high-level approach to project identification and selection. In summary, program staff 1) identify potential areas for research, development, and demonstration and collaborate with researchers to develop project proposals; 2) prepare or receive project proposals; 3) review project proposals with the RD&D Program team and SMEs, considering a wide range of evaluation criteria and the overall portfolio strategy; 4) refine scopes of work for approved projects, if necessary; 5) allocate funding following SoCalGas accounting policies; and 6) execute the project contract and initiate project research.

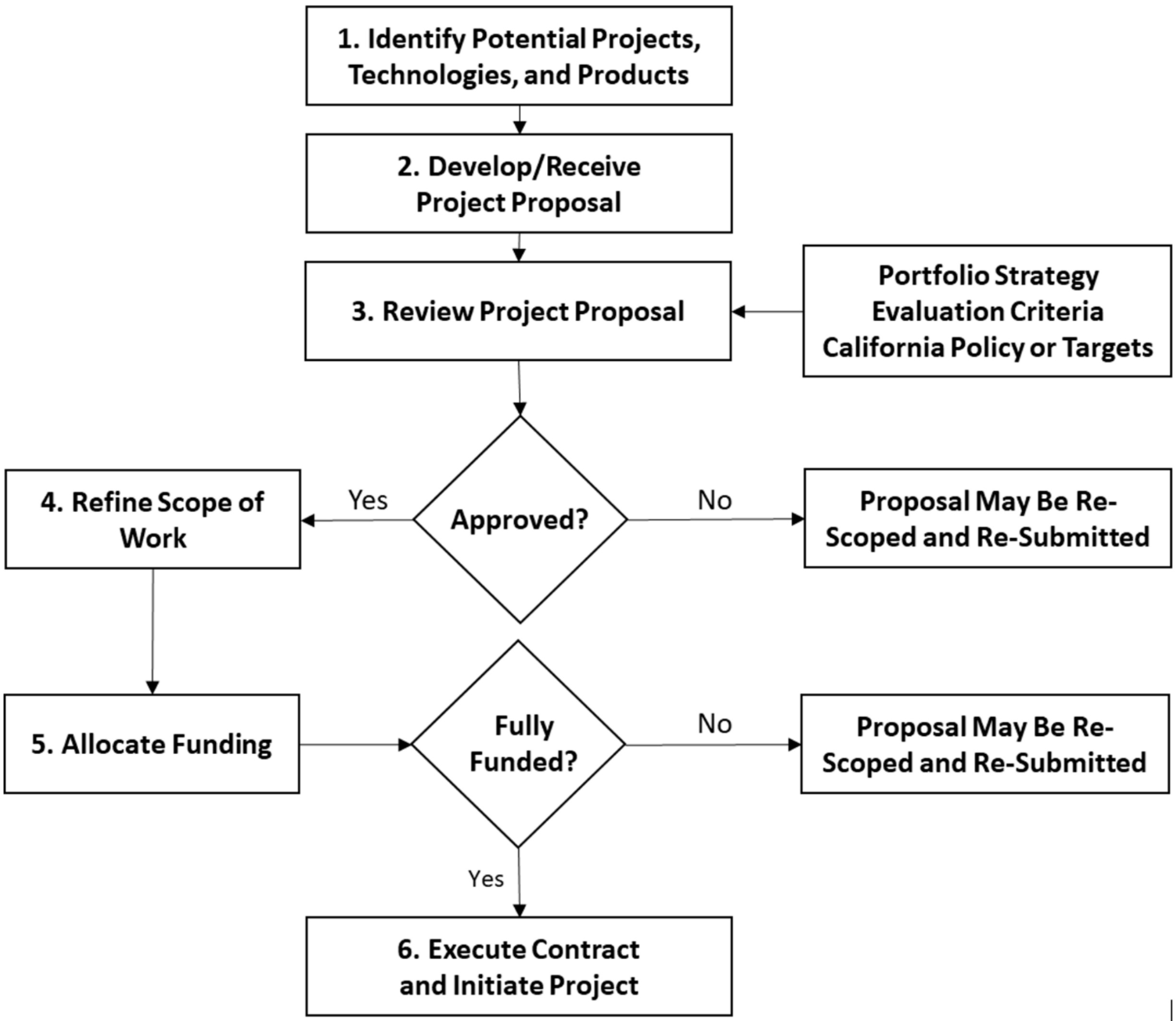


Figure 1: High-level internal RD&D project proposal review process.

During the internal project review process, RD&D Program staff evaluate potential projects using numerous selection criteria. Project selection criteria are based primarily on California Public Utility Code 740.1 which provides guidelines in evaluating the research, development, and demonstration programs proposed by electrical and gas corporations (Table 2). The criteria were also influenced by stakeholder input, industry best practices, and the RD&D staff's extensive experience evaluating research proposals. , Program staff do not numerically score potential projects or, necessarily weight the selection criteria for several reasons, including the need to retain flexibility to respond to changing market, policy and technical conditions while supporting promising projects, the diversity of types and scope of individual projects, and the variety of business needs and policy drivers.

Table 2: RD&D Program staff relied primarily on CPU Code 740.1 in developing project selection criteria.

Benefit	Relevant Section of CPU Code 740.1	Relevant Language
Customer Benefit	740.1a	“Projects should offer a reasonable probability of providing benefits to ratepayers.” "Each project should also support one or more of the following objectives:
	740.1e	(1) Environmental improvement. (2) Public and employee safety. (3) Conservation by efficient resource use or by reducing or shifting system load. (4) Development of new resources and processes, particularly renewable resources and processes which further supply technologies. (5) Improve operating efficiency and reliability or otherwise reduce operating costs.".
Lead Investigator/T Eam **Technical Feasibility** **Commercializ ation Potential**	740.1b	“Expenditures on projects which have a low probability for success should be minimized.”
Alignment with California Policy	740.1c	RD&D “Projects should be consistent with the corporation’s resource plan.” SoCalGas also considers guidance from stakeholders and regulators to ensure that projects support California’s environmental goals.
Co-funding Collaborators	740.1d	“Projects should not unnecessarily duplicate research currently, previously, or imminently undertaken by other electrical or gas corporations or research organizations.”

Equity	N/A	SoCalGas included equity in response to feedback from multiple stakeholders and regulators and was guided in part by the CPUC's ESJ Action Plan.

The 2023 project selection criteria are as follows:

Criteria	Description/Justification
Customer Benefit	RD&D Program staff also seek to advance a significant portion of the products, technologies, and solutions they help develop to the point where they can be implemented by SoCalGas and other utilities for the benefit of ratepayers. To assess this criterion, RD&D Program staff ask questions such as: Will advancing the proposed technology benefit gas utility ratepayers? If the technology becomes commercially available, how will it help SoCalGas customers, as well as internal (i.e., RD&D Program operations teams) and external stakeholders in a meaningful way? Does the technology address a key policy driver relevant to the SoCalGas service territory? Is the research new and not duplicative of previous or ongoing work by other research and development (R&D) organizations?
Alignment with California Policy	The RD&D team also seeks to align its program with key company, state, and federal objectives. To assess this criterion, RD&D staff ask questions such as: Does the project address a key California state policy driver or corporate initiative? Does the project advance the state of the technology along a development roadmap? Does the research address an internal operational need?
Lead Investigator/Team	Successful R&D Program teams need industry knowledge and technical skills to succeed, but they must balance these characteristics with soft skills, such as curiosity, perseverance, people management, and critical and strategic thinking. To assess this criterion, RD&D Program staff ask questions such as: Are the researchers, labs, or technology developers skilled and experienced in the space? Do they have a track record of success in executing research projects of a similar scope and successfully leading research teams? Do they have unique capabilities or facilities for conducting the required research? Do they have the skills and resources necessary to commercialize the proposed new technology?
Technical Feasibility	Although the RD&D Program team funds early-stage RD&D Program projects, it has a responsibility to ratepayers to fund projects with a high likelihood of success. To assess this criterion, RD&D Program staff ask questions such as: Has the technology been vetted internally or externally for

	feasibility? Is the basic science sound? Does the technology display favorable thermodynamic modeling or technoeconomic fundamentals? Does documentation of proof-of-concept work exist?
Co-funding Collaborators	One of the key objectives of the RD&D Program is to leverage the funds it uses to support promising projects with significant additional funding from other organizations, such as public agencies, universities, and private businesses. In fact, in 2021, every dollar of RD&D Program funds expended was matched by an average of $5.20 in funding from other sources. To assess this criterion, RD&D Program staff ask questions such as: Are other R&D programs, government agencies, or industrial entities collaborating on the project, either via co-funding or time and expertise? Can co-funding collaborators help validate and substantiate the feasibility of the technical claims? Is co-funding available to leverage the RD&D Program funding? Are other stakeholders supportive of the research? Is there consortium involvement to minimize the risk of duplicating work?
Commercialization Potential	Ultimately, RD&D Program staff seek to advance a significant portion of the products, technologies, and solutions they help develop to the point where they can be advanced to market in support of energy decarbonization, safety, and reliability. To assess this criterion, RD&D Program staff ask questions such as: Does the proposed level of funding match the technology readiness level (TRL)? Does a clear path to commercialization exist for the technology that this research advances? Is there immediate and anticipated future demand for the proposed technology based on defined market trends and competitive advantages in comparison to the status quo or alternative technologies? Does the project team bring sufficient financial support to the project to fund multiple years of development runway? Is the project team working with established commercialization experts who have proven track records with similar products or technologies?
Equity Considerations	The RD&D Program seeks to advance and champion products and technologies that support widespread access to clean, affordable, and renewable energy for all Californians, including those living and working in Environmental and Social Justice (ESJ) communities. To assess this criterion, RD&D Program staff ask questions such as: Does the proposed technology directly address the specific needs of a Disadvantaged Community (DAC) or Low-Income Community (LIC)? Is the project sited near a DAC or LIC? Does the project include engagement by a

	Community Based Organization (CBO) or Diverse Business Enterprise (DBE)? Is the Principal Investigator (PI) a member of an underrepresented population?

16 Appendix E: Project Details

The project data provided is a current snapshot of the RD&D project portfolio including all current projects that are multi-year continuing from 2022 into 2023 updated as of November 30, 2023~~as of May 1, 2022~~.
For clarity, we have mapped our data response to 16 data fields described in the Discussion sub-section titled ***Detailed budgets broken down by research subprogram*** of the resolution. Additional data fields have been added to address the requirements of Resolution G-3601.

- **a) Project title**
- **b) Unique number identifier for project**
- **c) Program and sub-program**
- **d) Project Start date**
- **e) Project end date or anticipated end date**
- **f) SoCalGas budget for project**
- **g) Total cost contracted**
- **h) Amount already spent**
- **i) Amount still to be spent**
- **j) Co-funding partners**
- **k) Monetary contribution of each co-funding partner**
- **l) Project benefits of research**
- **m) Research area**
- **n) Technology readiness level**
- **o) Next steps at end of project**
- **p) One-paragraph narrative description**
- **q) Actual Incurred Cost Jan-Nov '23**
- **r) Status**
- **s) Estimated Incurred Cost Jan-Nov '23**
- **t) Hydrogen Projects**

ATTACHMENT C

Advice No. 6273-G

Table describing proposed changes – RD&D 2023 Research Plan Revisions Roadmap

Page Number Range -Redline	Starting Page Number - Clean	Ordering Paragraph	Change Made	Document Section
1	1	N/A	Updated text to include revision information	Cover Page
5-8	5	N/A	Edited to reflect document updates	Table Of Contents
9-10	9	3b, 6e	Edited text to add new acronyms	Acronyms
13-15	13	N/A	Edited text to update information and provide summary/background of changes to document	Section 1
22-25	22	6d, 6e, 6f, 6g	Edited text to describe changes to RD&D program regarding equity engagement and UIAF efforts	Section 4.3-4.4
31-37	30	3a, 3b, 4, 7, 8	Edited text and included new tables to describe proposed reallocation of approved RD&D funds	Section 6.1
37-42	35	3f, 6b	Edited text to add additional information on research consortia dues and benefits	Section 6.2
43-44, 47, 50-51	41	3a, 3b	Edited text and tables to describe proposed reallocation of funds and retirement of disallowed sub-programs	Section 7
52-53, 55-59, 61	49	3a, 3b, 3c	Edited text and tables to address the resolution, and to relect the proposed reallocation of funds.	Section 8
62-63, 65-67, 69-72	58	3a	Edited text and tables to describe retirement of disallowed program	Section 9
73-74, 76, 78-79	68	3a, 3b, 8	Edited text and tables to describe proposed reallocation of funds and retirement of disallowed sub-programs	Section 10
79-80, 82, 84, 86-90	74	3a, 3b, 8	Edited text and tables to describe proposed reallocation of funds and retirement of disallowed sub-programs	Section 11
116	110	3f	Edited text to add additional information on benefits	Appendix D
122	116	3, 3b, 3c,	Edited appendix to add data fields	Appendix E
Attachment E	Attachment D	3, 3b, 3c,	Edited project list to reflect all continuing projects as of 1/1/2023	Appendix E

ATTACHMENT D

Advice No. 6273-G

Clean version of Appendix E – SoCalGas Research, Development and Demonstration Program Project Details REVISED 2023 Research Plan

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
2	1	AVNOS Combined Water and CO2 Direct Air Capture System	20210219225633	Low Carbon Resources	Low GHG Chemical Processes	Carbon Capture, Utilization and Sequestration (CCUS)	Low GHG Chemical Processes	10/1/2020	3/31/2024	$650,000	$3,135,447	$650,000	$0	$157,032	Retired	$0	DOE - $2,485,447	Environmental: GHG Emissions Reduction	Late Stage (TRL 7-9)	Field demonstration/testing	The objective of this project is to demonstrate the outstanding technical and economic performance of a transformational Hybrid Direct Air Capture ("HDAC") technology that simultaneously captures CO2 and water from the air. Air is passed over a CO2 selective sorbent to remove ≥85% of the CO2 from the air stream. The atmospheric water extraction ("AWE") section of the unit utilizes a novel isothermal pressure swing regeneration cycle with desiccant beds thermally coupled by heat pipes that provide a passive heat transfer mechanism to "cancel" the heat of water vapor adsorption. By proving system performance through a demonstration project, our initial technoeconomic analysis ("TEA") will be validated, showing that HDAC technology: 1) is deployable in many more locations with limited water resources, 2) improves the financial returns, and 3) reduces risks from volatility in the price of CO2. The end goal is field testing of the HDAC unit and preparation of a final report on the testing, results, conclusions, and recommendations; and a commercial analysis of the economic viability of the system and candidate locations for commercial deployment.	
3	2	Electricore Direct Air Capture Using Novel Structured Adsorbents	20210222231948	Low Carbon Resources	Low GHG Chemical Processes	Carbon Capture, Utilization and Sequestration (CCUS)	Low GHG Chemical Processes	10/1/2020	3/31/2024	$450,000	$4,530,280	$450,000	$0	$62,813	Retired	$0	Svante - $726,852 Climeworks - $704,846 DOE - $3,098,582	Environmental: GHG Emissions Reduction	Mid Stage (TRL 4-6)	Final report and demonstration	The proposed technical approach is to construct and operate an integrated Direct Air Capture (DAC) system, fielding and testing a novel combination of Climeworks' DAC process and hardware with Svante's transformational structured adsorbent laminate filter, advancing the process and identifying optimization options for this DAC configuration. Field testing will be conducted on a renewable power generation site in California to capture operational data on the novel process and material combination under real conditions. Data will be used to advise techno-economics and life cycle analysis of the technology. The objective of this project is to conduct applied research and development to address identified technical barriers on an existing, DAC system to drive down DAC cost to US$140/tCO2 for a 1Mt/y plant. A TRL 5 integrated unit will be deployed into the field for testing, producing a concentrated CO2 stream of at least 95% purity.	
4	3	PNNL Integrated CCU System (IC3M) for C1 and C2 Production Development	20210628235331	Low Carbon Resources	Low GHG Chemical Processes	Carbon Capture, Utilization and Sequestration (CCUS)	Low GHG Chemical Processes	9/1/2021	8/30/2025	$660,000	$3,300,000	$660,000	$0	$0	Retired	$0	DOE - $2,640,000	Environmental: GHG Emissions Reduction	Early Stage (TRL 1-3)	Final report	PNNL has been developing the Integrated Capture and Conversion of CO2 to Materials (IC3M) platform to make products from CO2 captured. This is a unique and promising technological pathway that can be explored in the utilization context of Carbon Capture. This project will explore C1- and C2-based material production from CO2.	
5	4	LLNL Modular Hybrid Electrobioreactor Demonstration	20220105098	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	3/1/2022	2/29/2024	$750,000	$2,030,000	$375,000	$375,000	$0	Active	$0	DOE - $1,000,000 Electrochaea - $280,000	Environmental: GHG Emissions Reduction	Mid Stage (TRL 4-6)	Final report and demonstration	The objective of this project is to scale up and deploy LLNL's in-situ electro bioreactors to determine the feasibility and economics of a commercial demonstration. In particular, goals of the project are to increase scale and productivity of current-gen reactors by at least two orders-of-magnitude, optimize electrode and flow field topology to maximize process efficiency, demonstrate successful fabrication of optimized electrode geometries, evaluate stability of the technology under variable electrical loads and variable feedstock purities, and develop technoeconomic models that will aid in demonstration of the technology.	
6	4-1	AVNOS Hybrid Direct Air Capture to Fuels Demonstration	20221025235330	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2022	10/31/2024	$500,000	$4,685,545	$375,000	$125,000	$157,032	Retired	$0	ONR - $3,935,545 Total Energies - $250,000	Environmental Benefits: GHG Reduction, Operational Efficiencies, Affordability	Mid Stage (TRL 4-6)	Final report and field demonstration	This project aims to build a commercially relevant demonstration unit to capture carbon dioxide (CO2) and water from ambient air and design a process for converting CO2 and water to zero-carbon fuels. The end-to-end method comprises IWVC's unique hybrid direct air capture (HDAC) technology and an electrically driven CO2 system to generate value-added e-fuels. The HDAC system enables self-contained (no external supplies needed, including water) production of CO2 and water. IWVC has received support from the Office of Naval Research (ONR) for this project, given the strategic importance of water and carbon-neutral fuel production for defense purposes.	
7	4-2	C4-MPC Microwave Catalysis for Process Intensified Modular Production of Carbon Nanomaterials from Natural Gas Development	2021030912832	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	5/5/2020	9/30/2024	$112,500	$3,753,721	$112,500	$0	$0	Retired	$0	DOE - $3,000,000 West Virginia University - $352,231 North Caroline State University - $176,490 H-Quest Vanguard - $150,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and prototype	The goal of this project is to design and develop a pilot demonstration microwave reactor system. C4-MCP is developing a low-cost, intensified modular process to directly convert methane into carbon-dioxide-free hydrogen and solid carbon with high conversion, selectivity, and stability. The intensified modular approach is key and will enable the unit's deployment. The method used in this project relies on using a microwave reactor to convert methane into hydrogen and carbon nanotubes (CNTs) and carbon nanofibers. Compared to other methane pyrolysis technologies, this technique demonstrates competitive energy efficiencies, regeneration of microwave catalysts, and high-quality CNT products that have the potential to offset the system's capital and operating expenses. In 2021, C4-MPC performed market and techno-economic analyses to identify commercial opportunities for the carbon nanomaterials produced in this process. To support these efforts, carbon nanomaterial products will be analyzed for their quality and potential commercial application. In 2022, the project team completed work in process optimization, catalyst development, and CNT product characterization.	
8	4-3	Captura CO2 Capture from Oceanwater Using Highly Efficient Electrodialyzer Demonstration	2021101945525	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2021	3/31/2024	$1,055,000	$1,702,267	$1,000,000	$55,000	$439,690	Retired	$28,986	Captura - $647,267	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and field demonstration	The project goal is to design, develop, and demonstrate the operation of a carbon dioxide capture system capable of extracting 100 tons/year from ocean water. Captura proposes the scale-up and testing of their technology in this project by building and demonstrating a 100-ton/year small-scale unit. The pilot aims to address the critical need to establish an integrated prototype device of the overall system at a large enough scale to assess cost levers and system scalability. In addition, the team will develop the system to demonstrate compatibility with real ocean water. The system has an ocean water intake rate of 700 gallons per minute and a carbon dioxide extraction rate of 100 liters per minute. A preliminary techno-economic analysis indicated that the Captura system could capture oceanic carbon dioxide for $500/ton at 1,000 tons/year and $100/ton at 1,000,000 tons/year. The project will test and validate the energy efficiency of capture, the purity of the captured carbon dioxide, and the stability and durability of key components in the system. The development and operation of the 100-ton/year system will provide vital data for estimating the cost of carbon dioxide capture and the scalability of the technology for a larger direct oceanic carbon dioxide capture system. In Q3 2022, the project team deployed a small-scale system at the Kerckhoff Marine Laboratory in Newport Beach, CA, to test the technology in real seawater conditions. In 2023, the group completed the primary carbon removal system fabrication and identified ocean filtration and water softening subsystems that would be required for deployment in real ocean water conditions. The team plans to complete the fabrication of the full system in early 2024.	
9	4-4	PNNL Methane Pyrolysis for CO2-Free H2 and Carbon Nanomaterials Co-Production Development - CRADA 576	20220906215850	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	10/13/2022	1/12/2024	$425,000	$425,000	$425,000	$0	$0	Retired	$0	N/A	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability Safety, Affordability	Mid Stage (TRL 4-6)	Final report and further scale up	This project builds up on the previous project with PNNL, C4-MCP, and DOE (through the H2@Scale program). The research team now seeks to develop PNNL's highly-efficient pyrolysis process for producing CO2-free hydrogen (H2) from methane while simultaneously looking for economic viable use cases for the carbon nanomaterial co-product. The use of this technology with renewable natural gas could reduce H2's net production cost to $1.0/kg through the sale crystalline solid carbon co-products while potentially producing hydrogen with negative carbon intensity.	
10	4-5	PNNL Production of CO2-Negative Building Composites Development - CRADA 553	202106280217	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	10/1/2021	10/31/2024	$540,000	$3,240,000	$540,000	$0	$0	Retired	$0	DOE - $2,700,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report and material formulation	PNNL has developed an integrated platform to capture and convert carbon dioxide (CO2) to Materials called IC3M. It created this platform supported by a Technology Commercialization Fund partnership with DOE-FECM and SoCalGas. Production of CO2 negative composite building materials using PNNL's Integrated capture and conversion of CO2 to Materials (IC3M) will be accomplished by chemically modifying lignin in wood waste streams to durably store CO2.	
11	4-6	Stanford Energy Efficient Strategies for Capture of Atmospheric CO2	2021101951218	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2021	12/31/2023	$130,000	$130,000	$130,000	$0	$0	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report	This project aimed to continue developing sorbent technology pioneered by Stanford University, which reacts with carbon dioxide in the presence of water and requires low regeneration energy. Traditional direct air capture (DAC) systems use basic metal oxides known to bind to carbon dioxide strongly and form carbonates but need extremely high temperatures to convert back into oxides. Stanford aimed to regenerate the metal oxide sorbent's post-carbon dioxide capture to avoid using high heat. Room temperature reactions, however, require more energy to overcome the respective activation barriers. Stanford developed energy-efficient non-equilibrium plasma and plasma-activated reductants to release carbon dioxide bound in carbonates and produce carbon dioxide-derived products to regenerate the sorbent. This project's novelty was exploring non-equilibrium plasmas that exist at low temperatures, can be powered by renewable energy, and can provide a sustainable way to capture and convert carbon dioxide. In 2022, the project team developed an experimental system to evaluate the use of plasma in DAC systems. The team studied the effects of inert and reactive plasmas on efficiency and performance during operation. The team also studied side reactions and other conversion mechanisms that occurred while using reactive plasmas. Results from this initial project will be used to inform potential future research activities.	
12	4-7	Susteon High-Capacity Regenerative Structured Sorbent Development for DAC Applications	202106280308	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	9/1/2021	8/31/2023	$25,000	$1,903,877	$25,000	$0	$0	Completed	$0	DOE - $1,500,000 Total Energies SA - $200,000 Cormetech Inc. - $100,000 Columbia University - $78,877	Environmental Benefits: GHG Reduction, Operational Efficiencies, Affordability	Mid Stage (TRL 4-6)	Final report and further scale up	This project aimed to develop a structured material assembly (SMA) for capturing carbon dioxide from the air. The purpose of this project was to optimize the composition of the SMA to maximize the carbon dioxide adsorption rate, sorbent renewability, and carbon dioxide capture capacity. With this project, Susteon advanced the SMA technology from a readiness level (TRL) of 3 to 4 to justify its scale-up and pilot test in a subsequent project. The goals of the bench-scale technology projects were 1) 50% improvement of structured direct air capture (DAC) sorbent carbon dioxide working capacity over the current lab performance; 2) 50% improvement of structured DAC sorbent carbon dioxide capture rate; 3) structured sorbent pressure drop less than 150 Pa; 4) stable carbon dioxide working capacity to make certain a 3 to 5-year replacement cycle; and 5) development of a low-cost scalable fabrication process for sorbent modules. This project kicked off in Q4 2021. In 2022, Susteon designed and built a 1 kg/day CO2 bench-scale DAC test unit to evaluate the structured sorbent system's performance. The project was completed in 2023 and has demonstrated carbon dioxide adsorption at ambient conditions and subsequent desorption using electrical heating. In addition, no degradation of the sorbent bed was observed when the system performed more than 250 cycles, and the pressure drop across the SMA was consistent and below the target value. Technology scale-up will proceed with additional support from the Department of Energy and other entities.	
13	4-8	Susteon Plasma Assisted Catalytic Conversion of CO2 and Propane to Propylene and CO Development	20200629213720	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	12/1/2020	6/30/2023	$120,000	$1,120,000	$120,000	$0	$0	Completed	$0	DOE - $1,000,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report	This project aimed to develop a novel Catalytic Non-Thermal Plasma (CNTP) process to synergistically combine low-temperature plasma with metallic/bi-metallic catalysts in a scalable reactor for utilizing CO2 as a soft oxidant to produce ethylene and propylene from ethane and propane, respectively. The team pursued the following objectives under this project: 1) design and modify an existing bench scale plasma reaction system for testing the proposed process, 2) perform catalyst preparation, characterization, and evaluation under relevant operating conditions, 3) experimentally investigate carbon dioxide oxidative dehydrogenation in the plasma reactor with and without catalyst, and 4) develop process modeling activities based on experimental results. This technology is very interesting because it can offer many advantages: low-temperature operation (100° to 300°C vs. 700° to 900°C for steam cracking), quick start-up time (minutes vs. several hours for steam cracking), wide turndown ratio, smaller footprint, multiple stops and starts capability, on-demand operation, and modularity. Test results have shown that the catalysts developed under this project can obtain propane conversion as high as 60% and propylene yield as high as 80%. The team concluded that plasma-assisted catalytic conversion of CO2 and propane into propylene and carbon monoxide could be commercially viable at scale, which may create a viable carbon utilization platform.	
14	4-9	Susteon Stanford Iron-Oxide Based Catalytic Methane Pyrolysis Development	20211020154723	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2021	12/31/2023	$500,000	$3,990,139	$100,000	$400,000	$0	Retired	$0	DOE ARPA-E - $1,915,139 DOE NETL - $1,500,000	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report and prototype	The main objective of this project is to develop and demonstrate a methane pyrolysis unit capable of producing 10kg H2/day at less than $2 H2/kg with co-production of carbon nanotubes at under $10/kg. Stanford University and Susteon have begun developing a methane pyrolysis process to produce high-purity hydrogen and carbon nanotubes from the catalytic pyrolysis of methane. This project explores developing a unique iron-based catalyst to produce carbon nanotubes and hydrogen in a fluidized bed reactor. The team will develop a process to regenerate and reuse the catalyst and create synthesis methods that can easily be scaled to produce commercial quantities of catalyst using existing manufacturing infrastructure. The project kicked off in Q4 of 2021, and work has begun to optimize the catalyst and revise the process design. In 2022, the team made several improvements to the reactor design, including integrating structured catalyst supports resulting in much higher solid carbon recovery yields.	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	**No.**	**Project Title**	**Project Number**	**Program**	**Sub-program**	**2022 approved new sub-program**	**Research Area**	**Start Date**	**Anticipated End Date**	**SCG Budget**	**Total Project Cost**	**Amount Already Spent**	**Amount Still to be Spent**	**2023 Actuals (1/1-11/30/2023)**	**Status**	**2023 Estimated (1/1-11/30/2023)**	**Co-funders & Co-funding contribution**	**Project Benefits**	**Technology Readiness Level**	**Anticipated Next Steps at End of Project**	**Project Description**	**Hydrogen Blending Projects**
15	4-10	AIChE RAPID Institute Modular Chemical Process Intensification (MCPI) Development	20211012214631	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	9/1/2021	8/30/2024	$15,000	NA	$15,000	$0	$0	Active	$0	DOE - $60MM over the next 5 years, other members contribute between $7,500-$30,000 a year	Operational efficiencies, affordability	Early Stage (TRL1-3)	Scout early technologies that can offer ratepayer benefits if successfully scaled	This is for a membership in the Rapid Advancement in Process Intensification Deployment (RAPID) institute, an organization led by the American Institute of Chemical Engineers (AIChE) and funded by the U.S. Department of Energy. Their intent is to support the development of early technologies in processing conversion, including renewable gas production, with the ultimate goal of improving safety and operational efficiency via process intensification. RAPID's DOE funds are allocated to support development of projects executed by the different technology developers. This organization provides to the Renewable Gas Production subprogram access to technologies that can become LCR program	
16	4-11	Caltech Hybrid Electrochemical and Catalytic Hydrogen Compression System Development	20220214205939	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	12/1/2022	12/31/2024	$300,000	$2,500,000	$300,000	$0	$0	Active	$0	DOE - $2,500,000	Environmental Benefits: GHG Reduction, Operational Efficiencies, Affordability	Early Stage (TRL 1-3)	Final report and further scale up	Researchers at Caltech propose to develop a hybrid electrochemical, catalytic approach for the generation of compressed hydrogen. This technology differs from water electrolysis in that it involves a two-step process in which the active media is first electrochemically charged and then sent to a catalytic reactor to generate hydrogen directly. A benefit of this catalytic compression technology is that hydrogen can be produced on-demand with no intermediary steps at high pressure (up to 700 bar), allowing it to be stored with no additional compression or used for vehicle refueling. Low-cost hydrogen in a power-to-gas-to-power (PGP) system can help enable gigawatt (GW) scale and affordable long-duration energy storage. The project will focus on the off-peak operation to decouple and leverage renewable electricity intermittency and pricing. With data obtained during testing, the team plans to develop a comprehensive techno-economic analysis (TEA) to model the costs and performance of the system under these conditions. The project team also plans to integrate the hybrid technology to compress low-pressure hydrogen generated via water electrolysis.	
17	4-12	EvolOH High-speed AEM Electrolyzer Manufacturing Development	2022110911119	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	12/1/2022	6/30/2024	$350,000	$500,000	$275,000	$75,000	$157,032	Active	$0	EvolOH - $150,000	Environmental Benefits: GHG Reduction, Affordability	Mid Stage (TRL 4-6)	Final report, further scale up, and commercialization	This project aimed to develop high-speed coating methods for anion exchange membrane (AEM) electrolyzer technology to increase overall manufacturing speed and capacity. EvolOH's electrolyzer technology combines the performance advantages of proton exchange membrane (PEM) electrolysis (pure water feed, fast response, load-following, pressurized hydrogen production) with the cheap, non-platinum group metal (PGM) materials used in traditional alkaline electrolysis. EvolOH has designed its technology to accommodate roll-to-roll manufacturing, which can achieve nearly an order of magnitude improvement in production rate over state-of-the-art electrolyzer manufacturing methods. Increasing electrolyzer production speed and reducing material costs represent a meaningful strategy to lower the levelized hydrogen costs and increase the domestic supply of hydrogen production equipment. The project team achieved high-speed coating in this process, previously identified as a major manufacturing bottleneck. The team also validated the performance and stability of electrolyzer cells and stacks developed using this production technique. In particular, the project team developed new and improved catalyst ink formulations, demonstrating improved performance and processability. As part of this project, EvolOH also participated in a third-party techno-economic analysis to validate their anticipated stack material and manufacturing costs and understand the cost savings that may be realized as they increase the manufacturing scale.	
18	4-13	Kore Biosolids Pyrolyzer Field Test	178111287	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	2/13/2017	3/31/2023	$1,500,000	$5,300,000	$1,500,000	$0	$376,877	Completed	$0	Kore Infrastructure - $3,600,000 SCAQMD - $1,000,000	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Late Stage (TRL 7-9)	Final report and demonstration	This project aimed to reduce risk and improve the potential for financing future commercial deployments by conducting field tests to verify component integrity at high temperatures, feedstock throughput, and gas product quality and composition. Kore Infrastructure developed a commercial-scale pyrolyzer that thermochemically converts biomass to syngas. The produced syngas—a mixture of methane, carbon monoxide, carbon dioxide, and hydrogen—can be converted to renewable natural gas or renewable hydrogen. The pyrolyzer also has the potential to accept and process waste streams, including forest thinning, municipal solid waste, and food waste. The project team demonstrated the operation of feedstock conveyance and drying, pyrolytic conversion, and gas cleanup and cooling. Construction at SoCalGas' Olympic Base concluded in late 2021. Commissioning activities for the pyrolyzer began immediately afterward. System operations and testing began in 2022. Kore gathered operation data on system performance to guide future development and deployment activities. After multiple successful system runs and data-gathering activities, the team decommissioned the system in Q1 2023.	
19	4-14	Linde HydroPrime HC300 (Distributed Steam Methane Reformer - SMR) Purchase for Integration with STARS and Other Low Carbon Hydrogen Technologies	2019110314642	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	11/15/2019	12/31/2023	$2,675,566	$5,675,566	$2,405,966	$254,600	$0	Active	$0	FirstElement Fuel - $3,000,000	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Late Stage (TRL 7-9)	Final report and demonstration	The project's objectives are to 1) deploy the Linde HydroPrime MIN HC300 hydrogen plant capable of producing up to 300 Nm3/hr of hydrogen and 2) support the integration of the Solar Thermal Reactor System (STARS) steam methane reformer (SMR) with the Linde plant. This integration will enable researchers to interchange the Linde-supplied reformer component of the HydroPrime MIN HC300 hydrogen plant with the STARS unit and other advanced SMR technologies. The integrated system will utilize the balance of plant components - water shift reactor, pressure swing adsorption, heat exchangers, gas processing, instrumentation and controls, and electrical - of the HydroPrime MIN HC300 hydrogen plant to handle and process both the feed stream and syngas output stream of the STARS unit and other advanced SMR technologies. Successful integration will demonstrate and validate the production of a pure hydrogen output stream using several advanced SMR technologies.	
20	4-15	NREL Biologically Derived Hydrogen From Organic Solid Wastes Research	20221101232254	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	12/1/2022	4/30/2024	$189,320	$394,320	$189,320	$0	$0	Active	$0	DOE HFTO - $180,000 NREL - $25,000	Environmental Benefits: GHG Reduction, Affordability	Early Stage (TRL 1-3)	Final report	The goal of this project is to test and identify suitable feedstocks for biotechnology developed at the National Renewable Energy Laboratory (NREL) that can produce hydrogen from organic solid waste streams rich in cellulose content. The core of this technology employs microbial, dark fermentation to harness the chemical energy and electrons in these wastes for hydrogen production. The NREL team has leveraged their expertise in microbial strain engineering and bioprocess design to create strains of Clostridium thermocellum and develop fermentation strategies that achieve high conversions of the organic solid waste streams to hydrogen. The project team plans to test their engineered microbes to enhance anaerobic digestion (AD) technologies by further processing cellulose-enriched "hard-to-digest" materials into hydrogen. These wastes may be from less complex sources (e.g., dairy residues) or highly complex sources (e.g., biosolids or sludges produced during municipal wastewater treatment). This carbon-neutral approach can potentially be carbon-negative when paired with carbon capture technologies. In addition to the ongoing work to evaluate these feedstocks, the project team will also work with researchers at Argonne National Laboratory to perform a detailed techno-economic analysis for this hydrogen production pathway. In 2023, the team sourced >10 unique waste biomass feedstocks and screened their activity for hydrogen production. Additional activities included compositional analysis to quantify the chemical makeup of the feedstocks which will inform further research, such as microbial strain modification, in 2024.	
21	4-16	NREL CRADA No. CRD-19-809 P2G Systems Integration & Optimization	20190415153550	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	5/1/2019	10/4/2024	$3,000,000 (in-kind)	$3,700,000	$3,000,000	$0	$6,281	Active	$0	DOE - $700,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Final report and field demonstration	The goal of this project is to integrate biomethanation and electrolysis to realize the synergies that the two processes have. Hydrogen's inherently low solubility in water can challenge power-to-gas biomethanation and other gas fermentation processes. This low solubility limits the availability of hydrogen to the biocatalyst. The methods are also burdened by the high capital costs of the water electrolyzer used to make green hydrogen. The National Renewable Energy Laboratory (NREL) is working to eliminate expensive hardware unnecessary in producing hydrogen for this purpose. By co-locating the electrolyzer with a chemical reactor, some of the sub-systems normally needed to produce pure "dry" hydrogen, which is necessary for fueling but not for processes like biomethanation can be removed. This approach could avoid thousands of dollars in equipment costs while improving system efficiency by preventing hydrogen losses or additional energy to dry the gas. These improvements resulted in a non-provisional patent application in 2021. During 2021, NREL completed the electrolyzer balance of plant design for the mobile biomethanation system and incorporated these innovations ahead of receiving a 20kW electrolyzer stack from Plug Power. In 2022, the team completed the advanced electrolyzer system design, removing unnecessary sub-systems and implementing a novel strategy to measure hydrogen flow rate using stack current from the electrolyzer. The team also worked with the University of Chicago and Perma Pure to develop technology to recycle water in the biomethanation reactor.	
22	4-17	NREL Multi-Party CRADA No. CRD-18-00775 Biomethanation to Upgrade Biogas to Pipeline Grade Methane	2019062123830	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	7/31/2019	3/6/2024	$644,900 (in kind)	$2,265,000	$644,900	$0	$0	Active	$0	NREL - $1,500,000 Electrochaea - $120,100	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Final report and field demonstration	This project aims to develop and de-risk an adaptable biomethanation process to upgrade biogas waste streams to renewable natural gas (RNG). The team designed and specified a lab-scale biomethanation bioreactor and the balance of plant needed to produce pipeline-quality RNG from biogas and green hydrogen. They based the design on lessons learned from operating the SoCalGas 700L bioreactor system at the National Renewable Energy Laboratory (NREL). In 2021, NREL designed and Parr Instrument Company built the lab scale 20L 18-bar pressure-rated bioreactor. They outfitted it with multiple ports for sensors. The bioreactor also includes multiple sight glasses for viewing and a high-speed camera to monitor gas mixing. The team will install the bioreactor in a custom 16' trailer that will travel to biogas sites to demonstrate the production of RNG. Data from this mobile system will be available to regulators to accelerate the certification of the RNG production pathway from biomethanation. In 2022, the NREL team worked with Argonne National Laboratory researchers to develop a life cycle analysis for the RNG produced from biomethanation. One major takeaway of this study was that the carbon intensity (CI) score of RNG produced via this pathway heavily depends on the CI and source of electricity used to power the electrolyzer. When using a fully renewable electricity supply, RNG made from biomethanation of swine manure-derived carbon dioxide is ~-100 g CO_2eq per MJ, demonstrating carbon-negative fuel production. The new mobile bioreactor system is expected to be operational and deployed to biogas sites by the end of the 2023 calendar year.	
23	4-18	STARS Corporation Electric Induction Steam Methane Reforming (SMR) Demonstration	2020031815556	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	4/1/2020	12/31/2023	$3,600,000	$7,500,000	$3,275,000	$236,303	$88,697	Active	$0	STARS - $3,900,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Mid Stage (TRL 4-6)	Final report and demonstration	The goal of this project is to demonstrate and deploy a novel, advanced steam methane reforming (SMR) process to produce renewable hydrogen. STARS Corporation is developing an advanced, highly efficient SMR reactor that utilizes electrical induction-based heating instead of combustion heating, eliminating NO_x formation. STARS' reactor design uses micro and mesoscale catalytic channels and efficient heat recycling to demonstrate record efficiencies in converting electrical energy and natural gas to produce hydrogen. STARS' reactor technology features modularized construction capability and a small footprint. This technology will support on-site storage and fueling operations for SunLine Transit's fleet of hydrogen-powered buses in Thousand Palms, California.	
24	4-19	Susteon Catalytic Non-Thermal Plasma (CNTP) Reactor Scale-Up Demonstration	20210628063	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	8/1/2021	6/30/2023	$500,000	$500,000	$500,000	$0	$191,903	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and further scale up	The goal of the project was to continue the development of the catalytic non-thermal plasma (CNTP) technology by building up a reactor capable of producing 10kg of hydrogen per day. This project follows up on CNTP technology developed in a previous project with the Jet Propulsion Laboratory, in which the technology was successfully demonstrated at lab scale. The CNTP reactor uses plasma to improve the conversion of methane and water into a hydrogen-rich syngas at much lower temperatures relative to other steam methane reforming technologies. Susteon also tested the use of the CNTP reactor in the production of sustainable aviation fuel from carbon dioxide and methane, which would create an opportunity for utilization of captured CO_2 to provide a new pathway to reduce greenhouse gas emissions in an otherwise difficult-to-decarbonize sector. The research team successfully operated the CNTP reactor using commercial nickel catalysts to demonstrate a hydrogen-rich product gas from methane and steam at 450oC for 200 hours. A 3-fold increase in methane conversion was observed with the introduction of plasma, reaching around 60% methane conversion. The team also investigated the use of the CNTP technology for Sustainable Aviation Fuel (SAF) production and collected important insights to direct the future investigation of this route. An updated techno-economic analysis (TEA) was also performed, resulting in a H_2 cost of around $2.65/kg.	
25	4-20	TCF-19-17586 LLNL Composite Sorbents - Enabling Economical Biomethane Production	20190912143734	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	10/15/2019	7/29/2024	$500,000	$750,000	$250,000	$250,000	$0	Active	$0	DOE - $250,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and demonstration	The goals of this project are to determine the economic and technical feasibility of a full-scale demonstration after the two-year project. Lawrence Livermore National Laboratory (LLNL) and SoCalGas are working to refine and demonstrate a new class of sorbents for upgrading raw biogas to biomethane. This approach offers the potential to reduce cost barriers to biomethane production significantly. This strategy would, in turn, allow small producers to leverage this renewable energy resource to generate revenue. The focus of the technology maturation activities are to 1) demonstrate the longevity of the sorbent over an industrially relevant time scale; 2) understand the effects of hydrogen sulfide contamination; 3) scale up sorbent production; and 4) scale up the system by approximately four orders of magnitude. In 2020, LLNL devised a new composite material formulation compatible with large-scale manufacturing and built and operated a lab-scale unit (LSU). The LSU is a bench-top, integrated, automated sorbent system suitable for long-term (1,000-hour) testing. In 2021, LLNL planned activities with Xebec to operate a small-scale pilot (SSP) of the LSU at Xebec's testing facility. In 2022, LLNL successfully scaled up sorbent production for use in the SSP. The target completion date for the SSP will be 2023. LLNL will produce a techno-economic analysis of SSP for future maturation activities.	

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1	**No.**	**Project Title**	**Project Number**	**Program**	**Sub-program**	**2022 approved new sub-program**	**Research Area**	**Start Date**	**Anticipated End Date**	**SCG Budget**	**Total Project Cost**	**Amount Already Spent**	**Amount Still to be Spent**	**2023 Actuals (1/1-11/30/2023)**	**Status**	**2023 Estimated (1/1-11/30/2023)**	**Co-funders & Co-funding contribution**	**Project Benefits**	**Technology Readiness Level**	**Anticipated Next Steps at End of Project**	**Project Description**	**Hydrogen Blending Projects**
26	4-21	UCR Speeding Anaerobic Digestion Through CO2 Microbubbles	20200513161417	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	6/1/2020	12/31/2023	$149,877	$299,877	$149,877	$0	$0	Completed	$0	CalSEED - $150,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Final report and demonstration	This project aims to introduce carbon dioxide microbubbles to increase methane generation rates in anaerobic digestors significantly. The project team collaborates with Riverside Water Quality Control Plant, which has sufficient digestion capability to dedicate two one-million-gallon digesters to this trial. One digester will serve as a control, and the team will operate it normally. The second will be the experimental digester with the Perlemax technology implemented into its heat exchanger recirculation loop. The team will compare results from the experimental digester to those of the control to determine if the carbon dioxide microbubbles statistically affect digestion rates. Initially, both digesters will start with the same sludge feed rate. The experimental digester will begin with a low flow of carbon dioxide microbubbles. The team will optimize sludge and carbon dioxide flow rates to maximize volatile solid conversion and methane production. Early in the project, the team completed the design and fabrication of the microbubble equipment. In 2023, the project team faced long delays due to an industry-wide shortage of carbon dioxide. A suitable carbon dioxide supplier was finally identified late in 2023. Installation, commissioning, and equipment testing will be completed in 2024.	
27	4-22	West Biofuels Renewable Gas Separation System and Techno-Economic Assessment	20190911193025	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	10/1/2019	12/31/2023	$200,000	$2,200,000	$200,000	$0	$0	Completed	$0	CEC - $2,000,000	Environmental Benefits: GHG Reduction, Affordability	Early Stage (TRL 1-3)	Final report and demonstration	The objectives of this project are to 1) assess the separation efficiency of gas hydrates in producing high-purity renewable methane from mixed alcohol tail gas and 2) to develop an integrated techno-economic model to calculate production costs and identify key cost drivers within the West Biofuels biomass-to-mixed alcohol process. Ongoing experiments validated the proof-of-concept by showing that, under appropriate thermodynamic conditions, gas hydrates selectively concentrate methane and higher molecular weight species within the mixed alcohol tail gas stream. Despite this validation, both the time necessary for hydrate formation and the lower-than-desired per-stage separation efficiency suggest that alternative or supporting separation processes may be required. Modeling efforts have focused on modifying existing National Renewable Energy Laboratory (NREL) mixed alcohol production models to reflect recent process modifications. In 2021, applying the gas hydrate separation concept in the continuous flow arrangement showed promise, meriting further investigation. Furthermore, other separation technologies—membrane and pressure swing adsorption—are being investigated to make sure successful project completion. In 2022, despite significant downtime due to equipment damage, repair, and supply issues, the team recommissioned the system to begin long-term testing runs, data collection, and analysis activities. Using data from these runs and natural gas separations modeling support from NREL, techno-economic analysis will be refined and reported in 2023.	
28	4-23	HyET Hydrogen -- Electrochemical Hydrogen Compression and Purification Skid Procurement	20200309233424	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	3/9/2020	10/31/2023	$651,245	$651,245	$651,245	$0	$41,745	Completed	$0	N/A	Reliability, Safety, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Mid Stage (TRL 4-6)	This HyET unit was decommissioned, removed from the host site, and stored. A new generation of this technology is being developed based on the learnings from the project.	HyET's Electrochemical Hydrogen Purification & Compression (EHPC) technology is based on the selective transport of hydrogen through a membrane electrode assembly. The primary objectives of this project were to procure a pilot EHPC skid to demonstrate the technology and to collect valuable performance data to help improve the efficiency and capital cost of the EHPC system in future commercial applications. The EHPC systems were designed for a nominal hydrogen production capacity of 10 and 100+ kg of hydrogen per day for a pilot and commercial scale, respectively. In 2021, the HyET EHPC skid was delivered to and successfully installed at SoCalGas' Engineering Analysis Center. Preliminary testing was completed and the unit is operating as designed, successfully demonstrating hydrogen extraction. The unit's operation is ongoing and continued to provide valuable testing data while blending hydrogen, in concentrations from 3 to 15%, with methane in a simulated pipeline environment. The equipment was decommissioned and removed from the host site in 2023, and a new generation of this technology is being developed based on the learnings from the project.	
29	GO1	Aboveground Service Tee Identification and Mapping System (8.20.j)	20201023195516	Gas Operations	Environmental & Safety		Safety - Damage Prevention	2/1/2021	2/16/2023	$25,287	$220,000	$25,287	$0		Completed		SCG $25,287.00 | OTD Members $194,713.00	Safety	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to test and demonstrate a three-dimensional electromagnetic technology to locate subsurface metallic infrastructure such as metal cutters in polyethylene (PE) service tees. Most locating technologies do not have high-accuracy antennae to find underground facilities with high confidence, much less with plastic. Knowing the precise locations of buried infrastructure has the potential to save money by mitigating dry-hole excavations. In 2021, the team used the project data to determine the accuracy and effectiveness of the pipe-locating technology in identifying metallic cutters in buried PE service tees, which generates an intrinsic and unique fingerprint. In 2022, sponsors provided a variety of service tees that were classified and tested, with the system yielding positive results of geospatial accuracy and pipe depth. The data was collected and analyzed to determine the accuracy of the 3D position (latitude, longitude, depth) of the service tee cutter and to distinguish the service tee cutters from other metallic anomalies, such as emplaced clutter, against data in the library. The project team found that the emplaced clutter creates a fingerprint that is not unique to any tee cutter and instead creates a false positive. Upon project completion, the team will present the results in a webinar and deliver the testing and field demonstration reports to sponsors. SoCalGas could benefit from the ability to locate subsurface metallics because it has the potential to reduce damage to its lines, which reduces damage to life, property, and community. .	
30	GO2	AERMOD NO2 Modelling Improvement Project-Dissemination of Results (CPS-11-5B)	20221007182248	Gas Operations	Environmental & Safety		Environment	12/14/2022	2/13/2024	$34,050	$61,732	$34,050	$0		Active		SCG $34,050.00 | PRCI Members $27,682.00	Improved Affordability and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Share/Publish Results	The project objective is to assess the performance of the American Meteorological/Environmental Protection Agency Regulatory Model (AERMOD), the U.S. Environmental Protection Agency's (EPA) compliance tool for estimating impacts from air pollutant emission sources. This model overestimates ground-level NO2, which could lead to unnecessary NOx reduction system retrofits and compressor unit replacements. Previously, SoCalGas worked with Pipeline Research Council International (PRCI), the Interstate Natural Gas Association of America Foundation, the American Petroleum Institute, and other trade associations to build a robust emission dataset to assess the AERMOD model and to develop recommendations for improving AERMOD. The project team also identified pathways and methodologies to enhance model impact estimates from reciprocating engines, completed additional analyses, and recommended model changes. In this phase of the project, PRCI and sponsors will support EPA as they implement model changes and present the results in a workshop disseminating the AERMOD modifications to the public. The knowledge transfer involves in-person and web meetings with EPA staff and supports an EPA specialty conference involving AERMOD experts in a panel discussion. A tool that accurately assesses emissions could assist in planning for air emission reductions.	
31	GO3	CEPM for Turbochargers (CPS-14B-08)	2017092264	Gas Operations	Environmental & Safety		Environment	1/31/2019	3/31/2023	$8,653	$102,101	$8,653	$0		Completed		SCG $8,653.00 | PRCI Members $93,448.00	Reliability, Improved Affordability, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop turbocharger performance models from the data collected from a variety of past PRCI projects, as well as new data collected at two compressor stations. The model will provide operators with technology capable of early detection of decreased natural gas engine turbocharger performance. This approach will enable them to schedule maintenance and repairs before the engine cannot meet emissions limits. The team completed model development in 2020. Closures related to the ongoing COVID-19 pandemic delayed the collection of additional data needed to refine the model and perform validation testing. In August 2021, the project team completed data collection and used the information to validate the performance monitoring model. The team finished the validation of the turbocharger model in 2022. However, the team encountered a problem with one of the two models, the turbine model, used in the overall turbocharger performance model. The turbine model requires further refinement to improve performance predictability. This problem has resulted in the team moving the completion date to the end of the first quarter of 2023. The final deliverable for the project will be a final report and the models to predict turbocharger performance. SoCalGas could utilize the models to support compressor management to improve turbocharger performance.	
32	GO4	Development and Evaluation of High Resolution Historical Climate Dataset Over California (GFO-19-501, Group 2)	2021010815138	Gas Operations	Environmental & Safety		Environment	6/30/2020	3/31/2024	$5,000	$1,368,550	$2,682	$2,318	$182	Active		SCG $5,000 | CEC (GFO-19-501) $1,363,550	Reliability and Safety	Late Stage (TRL 7-9)	•Deployment of Results •Share/Publish Results	Weather forecasting models are used to find utility infrastructure vulnerabilities in extreme weather events. Examples of such events include extremely dry conditions posing wildlife threats and extremely wet conditions causing floods and mudslides. The two climate models currently used for forecasting are: (1) West Weather Research and Forecasting Model for California "dry" simulations, and (2) Desert Research Institute's Weather Research and Forecasting model for California "wet" simulations. A California Energy Commission (CEC) project titled, "Development of High Temporal and Geographical Resolution Characterization of Historical Climatic Conditions in California (CEC GFO-19-501, Group 2)," was awarded to UC San Diego and Scripps Institution of Oceanography. It will assemble climate data from California between 1980 to 2019 to be used to improve both models for forecasting weather conditions. The goal is to provide models that will enable utilities to assess infrastructure risks associated with exposures to short-term and long-term extreme weather events. The datasets will be made available in the cloud to utilities and climate researchers. The model results will also be made publicly available. The project team has started compiling the datasets for higher resolution refinements. SoCalGas is participating on the Technical Advisory Panel for the project.	
33	GO5	Gap Identification Between Hydrogen & Natural Gas Pipelines Standards & Practices (5.21.s)	2021062216838	Gas Operations	Environmental & Safety		Safety	8/1/2021	9/30/2023	$5,502	$170,000	$5,502	$0		Completed		SCG $5,502.00 | OTD Members $164,498.00	Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Share/Publish Results	This Operations Technology Development project aims to identify gaps in regulations and other safety and industry standards where pipeline transport of H2-NG blends may not be addressed and potential solutions to address the gaps. Parts 190, 191, and 192 of Title 49 of the Code of Federal Regulations address safety and other requirements for transporting natural gas by pipeline. Natural gas pipelines are also covered by additional safety and industry standards (e.g., American Society of Mechanical Engineers, International Organization for Standardization). SoCalGas has prioritized reducing its carbon footprint and greenhouse gas emissions and is investigating using hydrogen-natural gas (H2-NG) blends to achieve this goal. It is, therefore, important to understand how these blends could impact SoCalGas' pipeline operations. The project team completed all tasks except the interviews with national and international hydrogen system operators and natural gas utilities investigating, experimenting, or looking to implement H2-NG blending, which will be scheduled and completed in Q1 of 2023. Upon completion of interviews, the team will compile all applicable codes and standards into a spreadsheet with an associated abstract summary for a gap analysis. The team will publish the results in a whitepaper that includes all hydrogen and H2-NG codes, standards, and practices; a gap analysis of H2-NG	Hydrogen-Blending Project The project was completed prior to Resolution.
34	GO6	Greenhouse Gases Emissions Reduction (SRP-GHG-01)	20210720172927	Gas Operations	Environmental & Safety		Environment	1/1/2021	12/31/2024	$32,339	$3,838,835	$32,339	$0		Active		SCG $32,339 | PRCI Members $3,806,496	Environmental: Reduced GHG Emissions	Mulitple - Program supports various projects.	•Mulitple - Program supports various projects.	Greenhouse gas (GHG) emissions are a global issue and have impact on the natural gas industry. Pipeline Research Council International established a Strategic Research Priority (SRP) to coordinate the efforts across all technical committees. The SRP goal is to provide a roadmap of projects researching means to significantly reduce GHG emissions from the natural gas transmission system. This information will provide the natural gas industry with GHG reduction solutions to implement and reduce its carbon footprint. The SRP funded and started eight projects in 2021: Regulatory Support for GHG Emission Reductions (CPS-11-09), Continuous Monitoring and Diagnostics for Facility Efficiency (CPS-14-06), Methods to Reduce Pipeline Blowdowns to Effectuate Repairs/Inspections (MATR-3-15), Flow Sensors for Continuous Monitoring and Diagnostics for Equipment Efficiency Monitoring (MEAS-5-28), Methane Leak Detection and Quantification (PL-1-08), and CPS-14-05 CFD Study of Prechamber Ignition Mechanism for GHG Reduction. More details can be found in the individual project summaries for: Fuel Reforming and Segregation as an Alternative for Compressor Fuel (CPS-14-07), Improvements in Facility Efficiency (CPS-17-07), and Reciprocating Engine Exhaust Methane Slip Reduction (CPS-17-08). In addition to the projects that started in 2021, two ideas are being considered for projects under GHG SRP: Low-Cost Instruments to Detect/Quantify Leaking Seals, Packings, or Dump Valves, and High Flow Sampler Replacement.	
35	GO6	Identify and Validate Best Practices for Applying Heat to Steel Near PE (5.19.s)	2019082322145	Gas Operations	Environmental & Safety		Safety - Damage Prevention	10/3/2019	3/31/2024	$103,117	$203,617	$103,117	$0		Active		SCG $103,117.00 | OTD Members $100,500.00	Reliability and Safety	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing; Modification to Regulatory, Policy & Standards; Deployment of Results; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to identify and validate best practices for applying heat to steel near polyethylene (PE) material. Field welding of steel pipeline components can transfer heat to adjoining PE material and affect its integrity. This study will consider possible worst-case scenarios in the field and the associated parameters needed to create a model that allows the user to simulate field conditions and predict the risk of heat damage to plastic facilities. The team worked on developing a preliminary simulation model with improvements aimed at reducing computational time. The team verified the physics behind the simulation. The project team is also developing and validating a standalone heat transfer calculator. It will include user inputs of critical parameters of welding, heat, pipe size, and local field conditions. The model will then calculate and display the maximum temperature at the PE-steel pipe interface. The calculator will also display a graphical representation of the 3D model. In 2022, the project team continued to fine-tune the conjugate heat transfer Multiphysics model and started the validation testing. This project benefits SoCalGas in reviewing and confirming best practices outlined in Company standards for welding near PE pipe, along with ensuring the integrity and safety of PE pipelines.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
36	GO7	Impact of Trace Constituents on Odor Masking (7.21.c)	20210127231347	Gas Operations	Environmental & Safety		Safety	3/1/2021	4/30/2024	$17,578	$150,000	$17,578	$0		Active		SCG $17,578.00 | OTD Members $132,422.00	Safety	Early Stage (TRL 1-3)	New Research Project to Advance TRL,	The objective of this study is to identify trace constituents that act as odor-masking agents. Natural gas contains numerous chemicals that are removed at gas processing plants before injection into the natural gas pipeline system. After treatment, trace amounts of these chemicals still exist in the processed gas. Some of these chemicals may act as odor-masking agents, preventing people from smelling gas leaks. The industry will use the study's results to determine how to mitigate the masking effect of these agents. The effort will lead to safer gas operations for utility workers and their customers. In early 2021, the team developed an odor masking test method to examine seven common masking agents found in gas processing plants. The team completed testing, and they identified the trace constituents of concern. Volunteers in laboratory sniff tests were to be employed to test those trace constituents. However, the project team delayed this last stage of the project due to health protocol concerns. The team is actively addressing the issues and anticipates that they will complete the sniff test in Q1 of 2023, along with the final report. Once SoCalGas receives the results, it will use them to determine if it needs to change its odorant program to protect ratepayers.	
37	GO8	Improving HCA Classification Methods (8.21.f)	20210111174145	Gas Operations	Environmental & Safety		Safety	3/1/2021	5/24/2023	$37,360	$184,000	$37,360	$0		Completed		SCG $37,360.00 | OTD Members $146,640.00	Safety and Operational Efficiency	Early Stage (TRL 1-3)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing; Technology & Knowledge Transfer/Training;	The objective of this project is to improve the accuracy of classifying high-consequence areas (HCA) and moderate-consequence areas (MCA) through modern data analysis and data sources. An HCA is an area where a release of natural gas would adversely impact the health and safety of the affected population. The current methodology used to define consequence areas is set by Pipeline and Hazardous Materials Safety Administration. This methodology allows for using outdated data that do not factor in population dynamics or development patterns in and around urban areas. Disregarding these fluctuating patterns in the model creates the potential for some areas to be misidentified. This misclassification exposes the impacted areas, the utility, and the general population to unnecessary risk. This project will explore the use of modern data sources and develop algorithms to automate the quantification of population or building use and size. In 2022, data acquisition and processing for the project study area continued. Additionally, the project began the data analysis by comparing the satellite vendor's building structure data to the project sponsor's data. SoCalGas intends to use this research to 1) enhance monitoring efforts in locating facilities that affect HCAs and MCAs and 2) explore alternative methods of monitoring the pipeline right-of-way for improving safety and compliance processes in accurately identifying HCAs.	
38	GO9	Living Lab for Hydrogen (M2021-008)	20210803205350	Gas Operations	Environmental & Safety		Safety	12/13/2021	12/28/2026	$300,000	$1,222,402	$95,629	$204,371	$27,962	Active		SCG $300,000 | NYSEARCH Members $922,402	Reliability, Safety, Operational Efficiency, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	•Deployment of Results •Share/Publish Results •Technology & Knowledge Transfer/Training	The goal of this project is to analyze and report data on the impacts of hydrogen blending at higher percentages (i.e., greater than 20 vol%) by evaluating safety, maintenance, and emergency response changes on gas distribution infrastructure and appliances. This is a SoCalGas project co-funded by NYSEARCH. The Living Lab demonstration aims to validate the feasibility of blending and injecting 20% or more hydrogen by volume into the existing natural gas infrastructure by simulating system operations with steel and plastic pipelines, a pressure regulator station, a compressor, and various end-use equipment. This project will yield valuable data on impacts to pipeline integrity, measurement, regulation, end-use equipment, and safety and maintenance procedures. .	Hydrogen-Blending Project 1) This project is necessary to research practical hydrogen blending limits on pipeline components to provide industry-wide benefits and influence the creation of SoCalGas standards and operating procedures. 2) This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: a) Evaluating H2 blend impacts on both medium (40 psig) and high pressure (100 psig), whereas our hydrogen blending pilot projects will evaluate H2 blending impacts on medium pressure systems only (greater than < 60 psig). b) Evaluating H2 at high concentration, from 25 vol% to 35 vol% H2, whereas our demonstration projects will evaluate H2 blends from 0.1 vol% to 20 vol%. c) Evaluating H2 blending impacts on a compressor, whereas our demonstration projects won't have a compressor component. d) Providing hands on, long-term, detailed data collection not possible with large scale demonstration projects (e.g. removing pipe components for inspection).
39	GO10	Low NOx Portable Analyzer	20230110234320	Gas Operations	Environmental & Safety		Environment	9/1/2022	5/31/2023	$76,360	$76,360	$76,360	$0	$18,580	Completed		SCG $76,360 | None $0.00	Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Share/Publish Results	The objective of this project is to investigate and experimentally determine the feasibility of an electrochemical portable analyzer test to measure low NOx and low CO emissions. The experimental outcome will include an assessment of (1) limits of detection, (2) stability, and (3) repeatability for NOx measurements less than five ppm and CO measurements less than 20 ppm. Portable emission analyzers using electrochemical cell technology have matured to provide reliable and accurate results. Recently, a PRCI project led EPA to accept new portable analyzer test methods. Portable analyzers are accurate enough to verify compliance with the low limits. Still, the need exists to push the technology and measurement even lower, which drives the limit of the technology. There is a need to understand the detection limit of portable analyzers and develop recommendations or additional provisions for ultra-low measurements, specifically in the 1.5 to 5 ppm range. The project tasks include developing a test plan and systematic testing in the laboratory and the field. The team will provide a final report detailing the limits of detection, stability, and repeatability for low NOx and CO measurements. Successful results may lead to regulators accepting the portable emissions analyzer as a valid measurement tool for verifying regulatory compliance for these ultra-low sources.	
40	GO11	Modify Pipeline Purging Program for Calculations of Methane Emissions Savings (5.17.m.2)	20200928212310	Gas Operations	Environmental & Safety		Environment	12/1/2023	12/31/2024	$17,072	$174,000	$17,072	$0		Active		SCG $17,072 | OTD Members $156,928	Safety, Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to add new capabilities to GASPurge, the existing pipeline-purging software used to calculate values associated with the purging and clearing of a natural gas pipeline. The project will add a variety of features, including alternative purging and clearing processes and equipment options, feasibility break even analysis, calculations of emissions savings, and quantification of gas not vented to the atmosphere. The updated software can support calculations for Greenhouse Gas (GHG) emissions and emissions saving reporting. Phase I of this project revamped the 1997 Gas Research Institute's Pipeline Purging Program, enabling its support by modern operating system platforms. The final Phase I deliverable was a commercially available software, GASPurge, that has been deployed and used by SoCalGas for gas purging operations. In 2023, the project team surveyed project sponsors to understand the type of equipment, methods, and processes they currently utilize for purging operations and alternatives to blow-downs. The survey feedback will be used for the next step to develop the software. SoCalGas anticipates using the updated software program when purging calculations are needed to determine safe purging parameters to improve safety and to support quantification of gas not vented to the atmosphere, a value needed for GHG emissions reporting.	
41	GO12	Odor Detection Study for Blended Hydrogen (M2021-005)	20210526154438	Gas Operations	Environmental & Safety		Safety	7/29/2021	1/31/2024	$21,835	$294,755	$21,835	$0		Active		SCG $21,835.00 | NYSEARCH Members $272,920.00	Safety and Operational Efficiency	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	The objective of this project is to determine if hydrogen blends can mask common gas industry odorants. Federal regulations require odorant injection into natural gas to provide the first line of defense for consumers to detect natural gas leaks. As utilities transition to new fuels such as hydrogen, there is a lack of data and information on the compatibility of odorants in blended hydrogen with natural gas. This study will investigate several natural gas odorants for detectability and recognizability when hydrogen, at various concentrations, is present. SoCalGas will use the results of this study to adjust odorant levels in hydrogen blends to maintain the ability of consumers to detect gas leaks.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Investigating whether hydrogen could interfere with the detection and recognition of the added odorants that are critical for safe operation. 2) Determining the detectability and recognizability of some primary natural gas odorant and odorant blends in the presence of hydrogen up to 20% by volume. 3) Project results will support the hydrogen blending pilot projects. The project completed the testing portion of this project prior to Resolution ordering the use of clean renewable hydrogen.
42	GO13	Odor Detection Threshold Study - Phase II, Tasks 1 & 2 (M2016-002)	20200102215137	Gas Operations	Environmental & Safety		Safety	11/16/2019	12/31/2023	$48,100	$468,950	$48,100	$0		Completed		SCG $48,100.00 | NYSEARCH Members $420,850.00	Safety	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	The objective of this project is to understand how the introduction of conditional factors of odor adaptation and odor-masking agents affect the detection and recognition thresholds of human senses. This project is Phase 2 of the natural gas odor detection threshold study and uses the odorant thresholds of human detection levels determined in Phase 1. The team studied the two phenomena in parallel, but they provided the results independently to understand each variable's effect better. This study can potentially inform decision-making regarding the odorization of natural gas. The contractor completed the odor adaptation task of the project. The study of odor-masking effects on odorants by masking agents, Limonene and Ammonia, was delayed in early 2021 due to the impacts of the COVID-19 pandemic. It established preliminary thresholds for Limonene in late 2021. In 2022, the team set the testing threshold for Ammonia. The study on Ammonia impacts will follow the Limonene study. The contractor was planning to perform the last stage of the project using volunteers to establish detection thresholds. However, this final stage was delayed since the contractor failed to meet the health protocols required by regulators. In the 3rd quarter of 2022, the contractor successfully met the required health protocols, and the last stage of the project is planned for late 2022. Once the team completes the last phase, they will publish the results in a final report. SoCalGas plans to use the study's results to evaluate if its odorant levels are adequate in its gas supply to safeguard the safety of ratepayers.	
43	GO14	ORFEUS Obstacle Detection Technology for Horizontal Directional Drilling (5.16.k.2)	2018071855	Gas Operations	Environmental & Safety		Safety - Damage Prevention	12/1/2017	3/31/2024	$62,346	$3,786,446	$62,346	$0		Active		SCG $62346 | OTD members $787,654 | PHMSA $993,970 | Others $1,942,476	Reliability, Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	•Commercialization •Share/Publish Results	Regulations require pipeline operators to mitigate geohazard and land use threats to pipeline integrity, particularly on slopes near river and stream crossings. In addition to applicable regulatory requirements, detecting and mitigating geohazard motion and ROW land use encroachment threats are primary elements of pipeline operators' damage prevention strategies and programs. This goal of this project is to develop improved methods for satellite-based tools and technologies to enhance detection of natural changes, seasonal flooding, erosional effects, channel dynamics, and ground movement affecting pipelines installed near river crossings. Successful completion of this project will identify three leading classes of satellites available in the market to support pipeline integrity programs, enhance operators' risk mitigation programs through more frequent high-resolution detection of risk factors, and right-of-way (ROW) surveillance. In 2021, the project continued with the synthetic aperture radar (SAR) data acquisition for four sites. Validation of change results against field data and high-resolution optical data is underway. A final report was drafted to summarize the results and methods for monitoring of ROWs at river crossings along with the capabilities and limitations of satellite technology. .	

No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
GO15	Pipeline Blending CRADA Phase 2 (Task 3, 4)	2020101615121	Gas Operations	Environmental & Safety		Safety	12/1/2023	12/31/2026	$75,000	$4,950,000	$0	$75,000	$0	Active		SCG $75,000 | DOE, Others $4,875,000	Safety, Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Share/Publish Results	The Pipeline Blending CRADA Phase 2 (a HyBlend Project) is a three-year effort amongst over 20 industry partners and four National Laboratories to evaluate the costs, benefits, and environmental impacts of blending hydrogen into the natural gas grid as a decarbonization strategy. Tasks were defined for investigation. SoCalGas is participating in tasks: 3) Lifecycle Assessment and 4) Techno-Economic Analysis. The lifecycle analysis will assess hydrogen-natural gas blend leakage throughout the supply chain and study hydrogen global warming potential with the inclusion of embodied emissions for a blended gas supply chain. The techno-economic analysis will involve two efforts that build upon previous research by adding improvements and capabilities to the Pipeline Preparation Cost Analysis Tool (PPCT) and assessing hydrogen blending integration into existing regional energy systems and the impact on coupled natural gas pipeline network and power grid systems. Outcomes of this effort will help researchers quantify the impacts of each system and guide best practice development on how to effectively implement hydrogen-natural gas blending to reduce overall energy system emissions and enhance energy system reliability. SoCalGas will use the results of this research to support the development of its blending standard and to understand the economic and technical aspects of efficient and effective implementation of hydrogen blending.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Supporting a on Life-Cycle Assessment (LCA) and Techno-Economic Analysis (TEA) that provides a model with a higher lever overview of the impact of hydrogen on all pipeline assets: transmission, distribution, and underground storage. 2) TEA and LCA results will support implementation decisions for the use of hydrogen within natural gas pipelines. 3) The hydrogen blending pilot will collect the data to use as an input for the TEA and LCA for the distribution system that will help improve the models. This project scope does not include testing using hydrogen.
GO16	Plastic Gas Pipe Damage Assessment due to high pressure water jets and cross bores (5.23.g)	2023011724210	Gas Operations	Environmental & Safety		Safety - Damage Prevention	12/14/2022	9/30/2024	$24,038	$125,000	$24,038	$0		Active		SCG $24,038 | OTD Members $100,962	Reliability, Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Early Stage (TRL 1-3)	Deployment of Results; Share/Publish Results	The objective of this project is to evaluate the effect of high-pressure (HP) water nozzles used in the sewer cleaning industry on polyethylene (PE) pipe materials to determine the impact on PE cross-bores. The team will work with industry leaders to identify multiple water nozzles used in the sewer industry, construct a testing rig, and develop guidelines to close the knowledge gap between safe and unsafe water jetting on cross-bores. Cross-bores are when PE pipe is inadvertently installed into sewers or sewer laterals. HP sewer pipe cleaning jets can create holes or damage PE cross-bores during sewer cleaning, resulting in gas leaks or more serious incidents. Currently, no standard or guideline limits the pressure and performance of sewer cleaning nozzles so they do not damage PE cross-bores. The deliverables for this project will be a final report detailing the results of the HP nozzle testing and a set of guidelines written by the project team for sewer cleaning and the use of HP water nozzles around plastic cross-bores. The team will standardize these guidelines and the test procedure so that new sewer cleaning nozzles can be tested and evaluated. The standards could benefit SoCalGas by reducing risk, improving safety and pipeline integrity, reducing costs associated with damage and resulting incidents, and informing SoCalGas' Integrity Management Plan.	
GO17	Reciprocating Engine Exhaust Methane Slip Reduction (GHG SRP CPS-17-08)	20210408135911	Gas Operations	Environmental & Safety		Environment	3/16/2021	12/31/2024	$22,046	$454,300	$22,046	$0		Active		SCG $22,046 | PRCI Members $432,254	Environmental: Improved Air Quality and Environmental: Improved Air Quality	Early Stage (TRL 1-3)	•Further Technology Development/Prototype	This Pipeline Research Council International Strategic Research Priority project is a multi-year effort to reduce criteria pollutants and greenhouse gas (GHG) emissions from legacy compressor engines. The project will investigate the effects of quenching the main chamber, nitrogen formation mechanism and pre-combustion chamber size, and an early ignition and seeding radicals in the main chamber. The initial planned literature review has been completed. The team is currently tuning the computational fluid dynamic model that will be used for pre-combustion chamber design and prototyping. Next steps include laboratory and field evaluation of the prototype. The results from this project could be used to retrofit legacy engines and changes in controls, which could lead to reductions in criteria and GHG emissions. Retrofitting legacy engines to reduce GHG and criteria pollutants is less expensive than replacing them. This option benefits ratepayers with a much more cost-effective alternative in combating climate change and improving air quality.	
GO18	Remote Gas Sensing For First Responders - Phase 4 (7.15.b.4)	20190919162242	Gas Operations	Environmental & Safety		Safety	9/1/2019	12/1/2024	$27,000	$358,000	$27,000	$0		Active		SCG $27,000.00 | OTD Members $331,000.00	Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing;	During natural gas leak investigations, first responders need the means to assess gas concentration outdoors, in manholes, and within buildings. Knowing the gas concentration remotely at multiple locations will save time and improve safety. This project aims to commercialize two instruments explored in previous phases of this project; these are the "First Responder" and the "Un-attended Methane Monitor" devices. In earlier phases of the project, a methane detection system prototype was developed to enable a leak investigator to remotely monitor methane levels at multiple points within a site under investigation. There are two objectives for Phase 4. The first is to develop pre-commercial units that can be tested by utility members. The second is to develop a wireless communication system to allow a leak investigator to monitor methane levels at multiple points remotely. In 2022, work started on design reviews for the mechanical assemblies. Initial integration of the project's mechanical, electrical, firmware and software components was completed as well as the first functioning prototype using silicone molded parts. The First Responder Mesh Network application has been developed as the GIZMO (Gas Investigation Zone Monitor). The prototype will be available for beta testing soon. Once the development of GIZMO is complete, further development of the Un-attended Methane Sensor will begin. Once this project is finished, SoCalGas will consider evaluating the technology for use in the field.	
GO19	Smart Shutoff Technology for Commercial and Residential Buildings (5.20.k)(CEC GFO-19-502, group 2)	20200109154639	Gas Operations	Environmental & Safety		Safety	8/4/2020	1/31/2024	$25,019	$1,200,000	$25,019	$0	$4,269	Active		SCG $25,019 | OTD Members $118,981 | CEC $1,056,000	Reliability and Safety	Late Stage (TRL 7-9)	•New Research Project to Advance TRL Level •Commercialization	This project is funded by the California Energy Commission (CEC) to improve the safety and integrity of natural gas infrastructure. The objective is to provide the natural gas industry with the necessary hardware and software components to create a full-solution, smart shut-off system capable of detecting and terminating gas flow in response to a hazardous incident such as fire, flood, or gas leak inside a residential or commercial structure. Deployment of smart shut-off systems can provide the localized detection and mitigation needed to prevent hazardous events from becoming excessively dangerous and costly. This project will demonstrate and validate the technologies needed to implement a smart shut-off system, as well as identify any gaps or barriers that need to be addressed prior to commercialization. In 2021 the project scope was modified to better understand the deployment of a Low Power Wide Area Network (LPWAN) at scale after identifying knowledge gaps in the communication methodology. In 2021, a Site Readiness Report was prepared along with a draft Hardware Validation Report. Field demonstrations for the Smart Safety Shutoff System are scheduled to begin in 2022. .	
GO20	Subsurface Multi-Utility Asset Location Detection (5.20.a)	20191213153110	Gas Operations	Environmental & Safety		Safety - Damage Prevention	12/1/2019	9/30/2024	$29,715	$2,094,494	$29,715	$0		Active		SCG $29,715.00 | OTD Members $175,668.00 | PHMSA $1,028,122.00 | Others $860,989.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The goal of this project is to conduct field trials on and subsequently commercialize a continuously locatable, on-pipe, electronic marking system using discrete radio frequency identification (RFID) to locate polyethylene (PE) pipes. PE pipes are not as locatable as their metal counterparts, and locating accuracy could be enhanced by a high-accuracy GPS locating system. The accurate location of buried PE pipe reduces the risk of third-party excavation damage. Ideally, the markers could be integrated into the pipe during the manufacturing process. Operators could use the system to document the location of subsurface plastic pipes, provide accurate GPS coordinates for pipes and points of interest, and assign a quality score to the location data that is then transferred to an operator's GIS. In 2022, the team continued working on optimizing the electronic pipe markers and enhancing the attachment methods for the markers to the PE pipe. The project team disagreed on whether electrofused or taped markers would be utilized. The methodology may differ by pipe size. Adding to the project delay was a change in the members of the project team which resulted in a reassessment of the path forward. PHMSA has granted an extension to the project end date.	
GO21	Tracking Software Development for Pipeline Safety Management System (8.21.h)	20210824142625	Gas Operations	Environmental & Safety		Safety	11/24/2021	5/24/2023	$21,464	$220,000	$21,464	$0		Completed		SCG $21,464 | OTD Members $198,536	Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	•Field Demonstration/Validation Testing	The objective of this project is to develop tracking software for Pipeline Safety Management Systems (PSMS) based on the American Petroleum Institute's (API) 1173 standard This standard addresses the program development and program performance assessments. The tracking software will develop a Key Performance indicator (KPI) and a scoring system to assist managers in evaluating the performance of their PSMS program. The software will aid in benchmarking PSMS performance for the continuous improvement process required under API 1173. With the software, utilities will continue to improve their PSMS to benefit ratepayers with a safer and more reliable service. .	
GO22	Validation of Next Generation Predictive Emissions Monitoring System for Gas Turbines (CPS-2-03)	20221007183148	Gas Operations	Environmental & Safety		Environment	11/1/2022	4/30/2024	$20,000	$65,000	$9,819	$10,181	$4,968	Active		SCG $20,000.00 | PRCI Members $45,000.00	Reliability, Operational Efficiency, Improved Affordability, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Share/Publish Results	The project objective is to validate the next generation of predictive emission monitoring systems (PEMS) for gas turbines developed by Siemens Energy. The Siemens PEMS is a turbine operating parameter-based system for predicting turbine emissions. This approach is less costly than continuous emission monitoring systems, which have high capital investment and operating costs. A PEMS could also be used as a diagnostic tool for evaluating turbine performance and optimizing downstream control equipment to reduce operating costs and	
GO23	Virtual Reality (VR) Training - Emergency Response Situations (5.18.t.2&3)	20191107214525	Gas Operations	Environmental & Safety		Safety	11/1/2019	6/23/2023	$80,000	$806,000	$80,000	$0		Completed		SCG $80,000.00 | OTD Members $726,000.00	Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Technology & Knowledge Transfer/Training	This GTI Energy project intends to develop a Virtual Reality (VR) content library and delivery system that utilities can use to assist in training their personnel on operation and maintenance procedures. This project will develop and use realistic, interactive, and immersive VR training modules that provide utilities with several operational advantages and guidance on deploying them. The project team will evaluate current VR technology to determine if new developments can enhance the VR training experience. SoCalGas using VR modules will improve learner retention, enhance the consistency of training delivered, allow operations to conduct training on demand, increase the number of real-life training scenarios available for trainees to experience, and reduce the risk of injury to trainees. The project team developed nine training modules, and SoCalGas evaluated this technology in 2022. GTI Energy is developing and re-developing the training modules on a new provider platform with an estimated completion date of March 31, 2023. GTI Energy created a draft implementation plan for SoCalGas in 2022 and will present the new modules, platform, and finalized implementation plan to the SoCalGas Training Department in early 2023. SoCalGas intends to implement this VR technology into its Training program.	
GO24	Work Zone Intrusion Detection and Warning System (8.22.g)	2022010601739	Gas Operations	Environmental & Safety		Safety	11/19/2021	12/13/2023	$9,333	$140,000	$9,333	$0		Completed		SCG $9,333 | OTD Members $130,667	Safety	Mid Stage (TRL 4-6)	•Deployment of Results •Share/Publish Results	The objective of this project is to perform market analysis and testing of Work Zone Intrusion Alarm (WZIA) technologies. Deliverables will include a Cost Benefit Analysis detailing features and pricing of the evaluated solutions and recommendations based on the various work zone scenarios that field crews may encounter. The goal is to improve the safety of employees and contractors working in situations where there is a possibility of work zone intrusion by unauthorized vehicles or pedestrians entering the work zone. Research suggests that implementing WZIA technology aids in the prevention of work zone injuries or fatalities. There is a broad range of functionality and cost between the various available technology solutions, but there is not a well-established marketplace, so further research is needed. The project is expected to kickoff at the early 2022. .	
GO25	3D Visualization Software for Mapping Underground Pipelines and Improving Pipeline Asset Management (8.20.m)(CEC GFO-19-502, group 4)	202001091765	Gas Operations	Operations Technology		Mapping and Locating Technologies	6/30/2020	3/29/2024	$89,349	$2,088,785	$89,349	$0		Active		SCG $89,349 | OTD Members $261,000 | CEC (GFO-19-502) $1,738,436	Reliability and Safety	Mid Stage (TRL 4-6)	•New Research Project to Advance TRL Level •Further Technology Development/Prototype •Commercialization	A significant amount of third-party damage to buried infrastructure is associated with inaccurate or insufficient locating practices. Knowing the location of the buried infrastructure can significantly aid in mitigating these risks and prevent damages. In this CEC co-funded project, GTI will develop 3D visualization software for mapping underground pipelines and improving pipeline asset management. To achieve this, several existing and proven technologies will be combined to create the Locate Technology Platform (LTP). This solution creates a set of business process models that an organization may implement to improve the three-dimensional geospatial accuracy of existing GIS data in both the horizontal and vertical dimensional directions. This platform assists the field users in visualizing infrastructure location data from a variety of viewpoints. Once the LTP is completed, it will be validated in a field demonstration. In 2021, software development began and data fields to be collected were identified. Efforts to create an in-office web application that would display GIS features in a 2D and 3D format from an accessible website are in process. .	

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1	**No.**	**Project Title**	**Project Number**	**Program**	**Sub-program**	**2022 approved new sub-program**	**Research Area**	**Start Date**	**Anticipated End Date**	**SCG Budget**	**Total Project Cost**	**Amount Already Spent**	**Amount Still to be Spent**	**2023 Actuals (1/1-11/30/2023)**	**Status**	**2023 Estimated (1/1-11/30/2023)**	**Co-funders & Co-funding contribution**	**Project Benefits**	**Technology Readiness Level**	**Anticipated Next Steps at End of Project**	**Project Description**	**Hydrogen Blending Projects**
55	GO26	Advanced Locating Technology with Exodigo (8.22.p)	20220823153734	Gas Operations	Operations Technology		Mapping and Locating Technologies	10/18/2022	3/31/2024	$77,648	$220,000	$77,648	$0		Active		SCG $77,648.00 | OTD Members $142,352.00	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Deployment of Results	The objective of this project is to evaluate the capabilities and performance of a non-intrusive subsurface mapping platform that uses multiple sensors and artificial intelligence to provide a digital geolocated representation of underground assets. The ability to map and locate existing underground infrastructure with increased accuracy and completeness of pipeline data supports damage prevention for gas utilities. The project scope includes performing a baseline evaluation of the technology at GTI Energy's pipe farm and a field demonstration at a sponsor location. The team will perform a comparative analysis between this technology and other locating technologies previously evaluated on the known underground pipe system at GTI Energy. The team will deliver a final report which will provide the analysis and comparative results and identify potential use cases within the natural gas industry. If this technology demonstration is successful, it could give the utilities another option for locating or mapping underground assets. SoCalGas may pursue its own field demonstration and evaluation after reviewing the project deliverables.	
56	GO27	Alternative Steel and Composite Material and Liquid Pipeline Systems (5.22.f)	20220112185929	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	12/14/2021	12/31/2024	$11,019	$1,008,320	$11,019	$0		Active		SCG $12,706 | OTD Members $135,000 | PHMSA $873,320	Safety and Operational Efficiency	Mid Stage (TRL 4-6)	•Field Demonstration/Validation Testing •Modification to Regulatory; Policy & Standards	The objective of this project is to establish a framework and corresponding requirements for the installation, inspection, and integrity management of alternative-steel and composite systems in natural gas pipelines. The study addresses: (1) material testing, (2) construction requirements, (3) damage and assessment of defects, (4) degradation of the pipe material, and (5) inspection and maintenance activities. The project is designed to map the requirements under 49 Code of Federal Regulations (CFR) Part 192. The goal is to identify and address the gaps in implementing a qualification process for non-steel and alternate-steel composites similar to the ones currently used for steel pipes. Pipeline Hazardous Materials Safety Administration held their kick-off meeting in November 2021 where they started forming the Technical Advisory Panel. The next steps are to hold an Operations Technology Development kick-off meeting and to begin evaluating material properties and testing procedures to determine how they might be modified to be applicable for the full range of modern materials. .	
57	GO28	Continuation of Single-Path Ultrasonic Meter Long Term Performance Testing & Monitoring (5.20.e.2)	20201222164438	Gas Operations	Operations Technology		Measurement & Regulation Operations Technologies	12/2/2020	12/29/2023	$5,375	$129,000	$5,375	$0		Completed		SCG $5,375.00 | OTD Members $123,625.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Field Demonstration/Validation Testing; Share/Publish Results	The objective of this project is to build upon research identified by Operations Technology Development (OTD) Project 5.19.h: Single Path Ultrasonic Meter (USM) Performance Testing (Phase 1). The project team will add a smart diaphragm residential gas meter (DRGM) to the earlier accuracy evaluation. An interim report provided performance testing results evaluating the effectiveness of the smart gas meter shut-off valve, enabling 1) comparison of the local distribution company's DRGM metrology results with the two ultrasonic meters (USMs) tested in Phase I and 2) evaluation of the communication capabilities of the three meters from both Phase 1 and this project. In this project, the team is evaluating the effectiveness of the smart shut-off valve and communication capabilities of all three meters. In 2021, the project identified the locating and mounting mechanisms, completed the setup of simulated power for replicating different battery capacity levels, and completed accuracy tests on all three meters for an outdoor accelerated life test. In 2022, all testing for the smart DRGM was completed, while testing for the USMs is ongoing. The next steps are to complete the USM testing and draft the final report. SoCalGas could use this information to supplement its evaluations of new metering technology for ultrasonic meters.	
58	GO29	Data Logger Evaluation Project - Phase II	20210702163440	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	6/15/2021	12/31/2024	$320,000	$320,000	$42,735	$277,265	$42,735	Active		SCG $320,000.00 | None $0.00	Reliability, Safety, and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to evaluate a commercially available data logging technology for collecting data associated with the fusion joint process. Thermoplastic pipeline joints are produced in the field using a pipeline fusion processes (e.g., heat and pressure). High-quality joints are critical to the integrity (e.g., safety and reliability) of natural gas pipeline facilities. There is presently no automated data collection process for field fusion operations. This process has significant potential for errors and is not an efficient means of integrating the fusion data into company systems, thus encumbering review and analysis. Furthermore, in cases of failure, the fusion data is not readily available for review to aid the investigative process. During the project's first phase, the team performed a proof-of-concept evaluation for a commercially available data logger. In phase II, the team is researching the process of data collection, storage, and integration into company systems. It is anticipated that the collected fusion data will allow real-time evaluation of fusion parameters such that fusion joints are produced with consistent quality before being placed into service. In 2022, the project team worked with a data logger manufacturer and a SoCalGas IT team to identify software developments needed for data integration into Company data management systems. Additionally, the team has worked on resolving technical issues with the data logger, continued to collect fusion data in the field, and conducted training for welding instructors. Moreover, the project team worked on preparing a plan for the next steps of this project. A final report describing the work performed, and the necessary software developments will be provided.	
59	GO30	Enhanced Locating Technologies for Underground Pipelines with Better Accuracy (8.20.l)(CEC GFO-19-502, group 3)	20200109162122	Gas Operations	Operations Technology		Mapping and Locating Technologies	11/4/2020	3/31/2024	$26,768	$2,222,903	$26,768	$0		Active		SCG $26,768 | OTD Members $207,146 | CEC $1,821,631 | Other Technology Providers $167,358	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	•Further Technology Development/Prototype •Commercialization •Share/Publish Results	The objective of this CEC-cofunded project is to improve the safety and integrity of underground natural gas pipelines by increasing the accuracy and availability of horizontal and vertical pipeline location information. The approach is based on enhancing and adapting aboveground, large standoff, 3D electromagnetic detection technology to locate buried pipelines. It will supplement the technology with an in-pipe mechanism to focus on congested areas and plastic materials. SoCalGas will focus on transmission infrastructure while PG&E will focus on infrastructure in congested urban areas. Improved tools are intended to provide access to three-dimensional data in near-real time, and the combined solution is anticipated to apply to most in-field conditions including varying pipeline material, depth, and surface cover. In 2021, gathering and analyzing data from the GTI test site with buried pipes continued. Planning of the 2022 field demonstration at SoCalGas started and a test plan was developed. .	
60	GO31	Enhancements to ASTM F2897 Encoding Standard for Gas Distribution Components (5.22.v)	20220606163551	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	6/17/2022	12/1/2023	$32,827	$151,000	$32,827	$0		Completed		SCG $32,827.00 | OTD Members $118,173.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards	The objective of this project is to review and affirm the underlying mathematical model and requirements within the American Society for Testing and Materials (ASTM) F2897 and to make targeted enhancements to its completeness and efficacy. In addition, a goal is to develop an implementation guide within the ASTM standard to aid the proper application and use of the system. After nearly a decade of existence and use, there is a need to review and enhance ASTM F2897 "Standard Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)." Polyethylene (PE) pipe and tubing manufacturers utilize this standard to incorporate a 16-digit barcode on the materials they produce for tracking and traceability purposes. The project team will review the standard and verify that all the gaps are addressed and that the standard provides the necessary information for all types of materials for successfully applying barcodes. This project is important as SoCalGas will eventually implement barcode scanning of materials in the field for improved tracking and tractability. The final deliverable will be the revised ASTM F2897 standard.	
61	GO32	Evaluation of Micro-Thermal Gas Metering Technology (5.22.d)	202201060215	Gas Operations	Operations Technology		O&M Technologies	11/19/2021	11/30/2023	$13,200	$132,000	$1,003,200	$0		Completed		SCG $13,200 | OTD Members $118,800	Reliability and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	•Field Demonstration/Validation Testing •Share/Publish Results	The objective of this project is to evaluate the accuracy and overall performance of micro-thermal gas metering modules while measuring hydrogen-blended natural gas and biomethane gas volumes. The microthermal gas meter module consists of a Micro-electromechanical Systems (MEMS) -based calorimetric microsensor. The MEMS measures the flow of natural gas using the thermal measurement principle. The sensor element is located on a membrane and consists of a micro-heater and upstream and downstream temperature sensors. The temperature distribution characteristics during gas flow are used to determine the gas velocity and the gas volume. It is integrated with signal conditioning electronics including memory for calibration data. Gas utilities are increasingly considering the proposition of transporting fuels of varying constituents. This includes low-carbon-based fuels such as hydrogen-blended natural gas and renewable natural gas. The source of these fuels varies and so does the gas compositions. A reliable metering technology that can be easily calibrated to varying gas compositions provides an additional layer of operational flexibility to gas utilities and enables the diversification of gas quality in the network. The project is expected to kickoff at the beginning of the second quarter of 2022. .	Hydrogen-Blending Project The project was completed prior to Resolution.
62	GO33	GNSS Consortium (5.7.p)	202301111022	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	12/14/2022	12/21/2023	$15,000	$245,000	$15,000	$0		Completed		SCG $15,000.00 | OTD Members $255,000.00	Operational Efficiency and Improved Affordability	Late Stage (TRL 7-9)	Technology & Knowledge Transfer/Training	The Global Navigation Satellite System (GNSS) Consortium intends to facilitate knowledge and information sharing on rapidly developing GNSS technology and to determine how to apply this information to daily utility operations. The project team will accomplish this through technology evaluations and integrations, workshops, pilot projects, demonstrations, best practices and standards, and general information sharing. The focus on technology evaluation helps reduce the cost and complexity of deploying GNSS for routine utility construction operations and maintenance activities. High-accuracy GNSS data collection is essential to a utility's geospatial data management and Geographic Information Systems (GIS) integrity. The GNSS Consortium was initiated in 2017. In 2023, GTI Energy will continue to perform demonstrations and inform the project sponsors about the latest innovations and research in the geospatial technology industry. The project team will upload all deliverables to the enhanced web-based library, including technology evaluation reports, multimedia materials, training documentation, a close-out webinar, annual workshop materials, and a yearly GTI Energy GIS Week presentation. By staying abreast of current and cutting-edge advanced GNSS technology, SoCalGas will be equipped to make informed investment decisions related to geospatial technology and benefit from enhanced operational efficiencies, regulatory compliance, improved quality of field-collected data, and improved system integrity. SoCalGas intends to disseminate the research to its internal stakeholders for implementation in daily operations. SoCalGas hopes to identify low-cost alternatives for geospatial tracking of high-volume distribution pipeline components.	
63	GO34	Guidance for H2/NG Blending Equipment Installation and Operations (5.23.p)	2023090822515	Gas Operations	Operations Technology		O&M Technologies	12/1/2023	5/31/2024	$23,349	$179,000	$0	$23,349		Active		SCG $23,349 | OTD Members $155,651	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Deployment of Results; Share/Publish Results	The project objective is to shape and develop safety practices for blending hydrogen into natural gas pipeline systems by identifying the requirements, steps, and procedures involved. The project will address this through 1) a multi-disciplinary team conducting experimental work, 2) model development derived from the experiments, 3) validation of the analyses through component-level testing, and 4) two case studies and a techno-economic analysis. This project should help understand the condition of existing pipeline assets when introducing hydrogen blends, quantify potential safety risks, and update integrity management practices for better risk management. This project will deliver a systemwide quantitative risk analysis model that can be used to improve the safety protocols of the studied cases and provide recommendations to better prepare gas utilities and facility operators for hydrogen blending at larger scales. SoCalGas intends to use this research in cooperation with other California Investor-Owned Utilities by incorporating the findings into a preliminary statewide hydrogen blending standard that the California Public Utilities Commission will regulate. If the project proves successful, SoCalGas can use the results in its pipeline integrity risk assessment program to determine safe pipeline and operating parameters for introducing hydrogen into natural gas infrastructure.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Providing results prior to the approval of the hydrogen blending pilot and support hydrogen blending pilot related projects. 2) This project will provide procedures and recommended practices to guide SoCalGas in planning and executing our hydrogen blending demonstartion projects. 3) The financial analysis will aid in understanding the investments required for hydrogen blending pilots and future natural gas system implementation. This project scope does not include testing using hydrogen.
64	GO35	In-Situ Ultrasonic Gas Flow Meter Flow Verification (MEAS-6-17C)	2023081402012	Gas Operations	Operations Technology		O&M Technologies	12/1/2023	6/30/2025	$14,465	$265,500	$0	$14,465		Active		SCG $14,465.00 | PRCI Members $251,035.00	Operational Efficiency and Improved Affordability and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop and test a prototype for applying the gas tracer ultrasonic meter (USM) verification method from previous research efforts in a field setting. Previous research efforts (Pipeline Research Council International projects: MEAS-6-17, MEAS-6-17A, and MEAS-6-17B) tested the proof of concept for an in-situ gas tracer verification method for USMs in natural gas service using helium and achieved an average error of ±0.05%. A prototype for verifying USM field performance without service interruption would provide cost savings by identifying issues sooner and more quickly, and from not having to remove the USM from service for flow verification. The project team is developing a functioning prototype to deploy the gas tracer method of USM verification, will provide a final report that includes field data that illustrates the performance of the method and prototype, and will then propose this method to be used as a recommended practice within American Gas Association's published Report No. 9 (AGA 9), Measurement of Gas by Multipath Ultrasonic Meters. If the prototype and methodology are successful and adopted by AGA 9, SoCalGas would utilize this prototype verification method for calibration use for in-situ USMs if it is available as a service offering.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
65	GO36	Market Study and Technology Assessment of a High Concentration Hydrogen Leak Detector (T-792)	2023010531032	Gas Operations	Operations Technology		O&M Technologies	11/23/2022	10/31/2023	$6,940	$71,127	$6,940	$0		Completed		SCG $6,940.00 | NYSEARCH Members $64,187.00	Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Further Technology Development/Prototype	The objective of this project is to perform a state-of-the-art study to identify technologies for walking and mobile leak survey instruments to detect up to 100% hydrogen. Molecules of hydrogen are smaller than those of methane, and at higher blended percentages of hydrogen (20% - 100%), hydrogen could leak and not be detected using existing methane and hydrogen sensors. These higher hydrogen percentages may require specific leak detection technologies or existing equipment retrofitting. The natural gas industry needs research to identify the parameters for choosing the correct leak detection device for gas blends containing over 20% hydrogen. The project team will deliver a shortlist of potential technologies for walking and mobile leak detection applications and a roadmap for technology evaluation and development. This project could benefit SoCalGas by providing a shorter-term solution for hydrogen leak detection for gas blends containing over 20% hydrogen, which could enhance safety, reduce emissions, and save time and capital in the transition to utilizing these blends. SoCalGas could take the results to determine if developing a leak detector for gas blends containing over 20% hydrogen is warranted and if this detector could be made commercially available.	Hydrogen-Blending Project The project was completed prior to Resolution.
66	GO37	Screening Remote Flow Monitoring and Control (5.22.u)	2017092276	Gas Operations	Operations Technology		O&M Technologies	10/31/2022	3/30/2024	$42,824	$130,000	$42,824	$0		Active		SCG $42,824.00 | OTD Members $87,176.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Share/Publish Results; Technology & Knowledge Transfer/Training	With the increasing amount of renewable natural gas (RNG) in the distribution network, Distribution System Operators now have an additional role in managing the volume of gas from multiple injection sources. As the industry transitions, smart technologies could aid in the remote operation and flow management of the natural gas infrastructure. The objective of this project is to perform a review and screening of the latest advancements in smart and remote equipment applications for distribution systems. The project scope includes 1) identifying operator requirements and needs, 2) performing a market study to review the latest remote equipment and related communication systems, and 3) determining which products are in development and which are commercialized. The remote equipment includes on/off valves, regulation valves, pressure reduction gas stations, and backflow compressors. The project team will deliver a final report at the end of the research to include the industry needs and market product gaps for remote flow monitoring technologies. Future District Regulator Station designs will consist of proven remote monitoring and control equipment that will further enhance the operational safety and flexibility of the system and allow for RNG capacity.	
67	GO38	Targeted Hydrogen Blending in Gas Infrastructure for Decarbonization (GFO-21-507)	2022111424816	Gas Operations	Operations Technology		O&M Technologies	12/9/2022	3/31/2026	$15,000	$7,216,729	$6,726	$8,274	$6,726	Active		SCG $15,000.00 | CEC $5,658,000.00| Others $1,543,729	Reliability, Safety, and Environmental: Reduced GHG Emissions	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Modification to Regulatory Standards & Policy; Deployment of Results	The project objective is to shape and develop safety practices for blending hydrogen into natural gas pipeline systems by identifying the requirements, steps, and procedures involved. The project will address this through 1) a multi-disciplinary team conducting experimental work, 2) model development derived from the experiments, 3) validation of the analyses through component-level testing, and 4) two case studies and a techno-economic analysis. This project should help understand the condition of existing pipeline assets when introducing hydrogen blends, quantify potential safety risks, and update integrity management practices for better risk management. This project will deliver a systemwide quantitative risk analysis model that can be used to improve the safety protocols of the studied cases and provide recommendations to better prepare gas utilities and facility operators for hydrogen blending at larger scales. SoCalGas intends to use this research in cooperation with other California Investor-Owned Utilities by incorporating the findings into a preliminary statewide hydrogen blending standard that the California Public Utilities Commission will regulate. If the project proves successful, SoCalGas can use the results in its pipeline integrity risk assessment program to determine safe pipeline and operating parameters for introducing hydrogen into natural gas infrastructure.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Identifying the requirements, steps, and procedures involved with blending hydrogen into natural gas pipelines for industrial applications, whereas our demonstration projects will evaluate residential applications. 2) This project examined hydrogen blending impacts on component level, such as turbines and compressors, and on system level for industrial and power generation applications, whereas our demonstration projects will evaluate residential applications. This is not a live blending project and will analyze impacts downstream of the customer meter. 3) Project results will support the baseline assessment for the use of hydrogen within natural gas pipelines including the hydrogen blending pilots. This project scope does not include testing using hydrogen.
68	GO39	Technology Testing Assessment Facilities (AMI Smart Metering)	20200114225427	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	1/1/2019	12/29/2023	$124,300	$124,300	$124,300	$0	$1,810	Completed		SCG $124,300.00 | None $0.00	Reliability, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Feasibility/Proof-of-Concept; Further Technology Development/Prototype; Technology & Knowledge Transfer/Training	This project aims to evaluate new technologies, tools, and equipment at the SoCalGas Gas Meter Test Rack or Situation City. A frequent challenge faced by utilities is the need to find tools or technologies that increase safety, lower operation and maintenance costs, improve accuracy, and replace existing obsolete equipment and tools. SoCalGas has constructed its test facilities to simulate portions of the company's operating system. This approach enables the evaluation of new tools or technologies without impacting system operations or customers. Technology performance that passes the minimum requirements may be approved and deployed in company operations. Currently, the Measurement Technology Group is evaluating the functionality and reliability of a residential ultrasonic gas meter and an advanced metering infrastructure (AMI) network. This proof-of-concept pilot project leverages a new AMI network to receive real-time data from gas meters, multi-variable sensors, cathodic protection test stations and supports an integrated distribution automation system. To date, meters were tested and then returned to the manufacturer so that they could address concerns of inaccuracy. In 2022, the manufacturer delivered updated meters that addressed the previous measurement and communication issues for the accelerated life accuracy testing. The meters passed ANSI B109 testing and are currently installed on the test rack, with testing scheduled to be completed in early 2023.	
69	GO40	Ultrasonic Meter Demonstration	20240104184237	Gas Operations	Operations Technology		O&M Technologies	12/1/2023	12/31/2025	$750,000	$750,000	$0	$750,000	$0	Active		SCG $750,000.00	Reliability, Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing; Commercialization; Deployment of Results	The objective of this project is to demonstrate and pilot ultrasonic residential meters to evaluate their functionality and to develop a data collection and analysis process. This self-diagnostic meter contains an accelerometer with a valve at the gas inlet and uses the speed of sound to measure gas flow, records gas pressure, and temperature. New safety analytic data for meter pressure, temperature, seismic activity, and flow will enable greater proactive safety outreach and response. The project has completed the necessary meter testing criteria to allow the meter to be deployed to support the use of ultrasonic meters for new business and planned meter changes. Each meter will have a cellular line to transmit the meter's data to a cloud-based system and can send a remote valve closure command with an alarm for gas temperature and pressure readings outside the set range. SoCalGas anticipates the research findings on the new safety analytic data for meter pressure, temperature, seismic activity, and flow will enable proactive safety outreach and response.	
70	GO41	A Framework for Improved Geohazard Monitoring, Data Integration, and Information Fusion at Scale (OTD 5.24.i)	2024011022308	Gas Operations	System Design & Materials		Geohazard Design	12/1/2023	11/30/2026	$4,929	$819,252	$0	$4,929		Active		SCG $4,929 | OTD Members $58,624, PHMSA $399,252, Others $356,447	Reliability, Safety	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to develop a framework and architecture for geohazard data that could be integrated into models for monitoring and forecasting geohazard risks. This Pipeline and Hazardous Material Safety Administration co-funded project will combine government and industry monitoring data, and geohazard and pipeline inspection, into the design of the framework to be used in geohazard models. The project team will standardize the data so it can be streamlined and integrated into a network of different models for geohazard monitoring and forecasting, thus saving time and processing. Furthermore, where possible, real-time data will be standardized for use in models. The approach will improve geohazard monitoring and forecasting to mitigate geohazard risks and improve pipeline safety. This is the first stage in the development of the type of system SoCalGas wants to implement in the future to monitor, forecast, and mitigate geohazard risks. If this project is successful, it will benefit the ratepayers as it will provide utilities a more efficient and holistic way to monitor, in real time, any threats to our system and may give us early warning detection to take preventative measures in sufficient time.	
71	GO42	Action Limits for RNG Specifications (7.23.k)	20221123205646	Gas Operations	System Design & Materials		Gas Composition And Quality	12/1/2022	6/30/2025	$543,445	$1,256,000	$543,445	$0		Active		SCG $543,445.00 | OTD Members $712,555.00	Reliability and Safety	Early Stage (TRL 1-3)	Share/Publish Results	The objective of this project is to monitor available literature and gather operational data to support renewable natural gas (RNG) action limits for trace constituents. In 2020, the California Public Utilities Commission (CPUC) approved the Standard Renewable Gas Interconnection Agreement, which included a requirement to provide action-level specifications for ammonia, mercury, and siloxanes. Previous research determined that additional studies are needed to assess the effects of trace constituents on the natural gas pipeline infrastructure and end-user equipment, particularly mercury, on non-cryogenic end-user equipment. The project team will refresh the literature review for mercury studies and develop an experimental plan for laboratory testing at Southwest Research Institute for a future research project. The California utilities can benefit from this research since it fulfills a CPUC regulatory directive and supports pipeline integrity with a future recommendation on action limits.	
72	GO43	Alternative Caps for PE Service Tees (5.16.b)	164311228	Gas Operations	System Design & Materials		Materials and Equipment	2/15/2016	4/26/2023	$32,115	$112,400	$0	$32,115		Completed		SCG $32,115.00 | OTD Members $80,285.00	Reliability, Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to develop an alternative cap design for polyethylene (PE) tapping tees. The alternate cap design enables the PE cap to be fused onto the tapping tee tower rather than having a cap that threads onto the tapping tee tower. A threaded cap has more potential for leakage due to inadequate O-ring seal engagement. A fused cap decreases the risk of leakage. Developing a fusion cap and tapping tee assembly has limitations, and the fitting developer requires alignment tools for performing socket fusion on the tee tower. Due to the cost of alignment tools needed for the operation, and the limitations in the original design, the project team developed a new design. Samples of the re-designed alternative caps are being manufactured and will be sent to sponsors for evaluation in 2023. SoCalGas can use this research as a reference to improve the integrity of PE piping systems and minimize operation and maintenance costs to repair leaks caused by threaded cap design.	
73	GO44	ARPA-E REPAIR Program (TTSP)	20201028143729	Gas Operations	System Design & Materials		Materials and Equipment	10/1/2020	9/30/2024	$10,000	$3,2564637	$2,630	$7,370	$1,440	Active		SCG $10,000.00 | DOE $32,554,637	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mulitple - Program supports various projects.	•Mulitple - Program supports various projects.	Old cast iron, wrought iron, and bare steel natural gas distribution pipes make up 3% of utility pipes in use, but account for a disproportionate number of gas leaks and pipe failures compared to newer steel pipe. The ARPA-E REPAIR program seeks to reduce natural gas leaks from these pipes by developing a suite of technologies to enable the automated construction of new pipe inside existing pipe. REPAIR will advance the state of gas distribution pipelines by incorporating smart functionality into structural coating materials and by developing new integrity/inspection tools. It will also create three-dimensional maps that integrate natural gas pipelines and adjacent underground infrastructure geospatial information with integrity, leak, and coating deposition data. SoCalGas involvement with the project is through the Testing and Technical Specification and Steering Panel Committee. In 2021, technical input was provided by operators. Draft test plans developed by the Testing and Analysis Team were sent out for comment in preparation for external loading, pressure and pressure testing on cast iron and bare steel pipe. .	
74	GO45	Corrosion Control Knowledge and Technology Integration for Safer California Natural Gas Pipeline System (GFO-21-506, Group 1)	20221121161346	Gas Operations	System Design & Materials		System Design	10/20/2022	12/31/2025	$5,000	$1,205,000	$100	$4,900	$100	Active		SCG $5,000.00 | CEC $1,000,000.00 | Others $200,000.00	Reliability and Safety	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish Results; Technology & Knowledge Transfer/Training	The project objective is to develop an integrative approach for corrosion control of natural gas pipelines based on mitigation, monitoring, inspection, evaluation, and prediction. The research will address integration barriers with instrumentation, software, and training related to natural gas system integrity management, pertaining to microbially and soil property-influenced corrosion. The goal is to formulate a performance-based, cost-effective risk assessment and management approach and test the methodology in collaboration with pipeline operators in California. The project deliverables include: 1) evaluate corrosion detection technologies and improve existing and emerging pipeline inspection technologies; 2) integrate several corrosion risk models; and 3) develop a toolkit that could improve the accuracy, validity, and accessibility of data collection. The project plan is to develop training to increase data collection efficiency and accuracy and to validate the effectiveness of the Corrosion Risk Management toolkit with pipeline operators. SoCalGas believes that continued corrosion research is a necessary step in a good corrosion management process, and this project has the potential to benefit both California ratepayers and stakeholders by validating an advanced corrosion assessment methodology. SoCalGas will utilize the results of this research to evaluate and possibly augment its existing corrosion assessment processes.	

	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
75	GO46	Crack Management Analysis Tool	20190904144711	Gas Operations	System Design & Materials		Risk Design and Modeling	12/29/2023	12/30/2024	$29,700	$152,000	$0	$29,700		Active		SCG $29,700 | Others $152,000	Reliability, Safety, Improved Affordability	Late Stage (TRL 7-9)	Commercialization; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to support the development of an advanced web-based platform to help operators with post-processing in-line inspections (ILI) and non-destructive evaluation data for crack management. Utilities sometimes are limited to traditional Excel spread sheets to perform crack analysis or depend on third-party vendors to post-process sensitive information. This research will fill in the technology gap to help operators input large data sets and perform advanced analysis to help mitigate crack features on steel assets. The web-based platform will include crack evaluation, cycle counting analysis, refinement and evaluation of hard –to-spot crack features, probabilistic evaluation tools, flaw types (e.g., mechanical damage, corrosion), and multi-flaw remaining strength calculations. Project kickoff is scheduled for early 2024. Project deliverables include a web-based application, quarterly crack management workshops, and knowledge transfer. Results obtained from ILI inspections with crack detection tools will be deployed and evaluated using this web-based application. As SoCalGas increases its inspections of pipe segments using crack detection tools, the results of the research could optimize the effectiveness of inspection results and allow better understanding and assessment of pipe segments susceptible to cracking.	
76	GO47	Deliver Comprehensive Metal-Loss Assessment Criterion (EC-2-10)	20190907203828	Gas Operations	System Design & Materials		Pipeline Design	4/1/2019	4/30/2024	$133,902	$1,587,263	$133,902	$0		Active		SCG $133,902.00 | PRCI Members $1,453,361.00	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Modification to Regulatory, Policy & Standards; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop Level 1 and Level 2 metal-loss assessment criterion that are easy to use and covers all pipe grades and construction eras. The metal-loss assessment criterion will indicate the risk of leak and rupture, reduce inspection data scatter, and eliminate maintenance that does not affect risk reduction. The project integrates and builds on work completed in prior research, which developed a criterion for metal-loss assessment demonstrated in an independent evaluation to significantly reduce data spread and address bias in contrast to the American Society of Mechanical Engineers (ASME) B31G and Modified B31G. These assessments will have less scatter and conservatism than ASME B31G, Modified B31G, and other assessment models without compromising pipeline operational safety. The project has four phases. Phase I was completed by developing a burst pressure predictive model for isolated metal loss that captures the effects of length, depth, width, planar shape, and longitudinal profile with the results provided in an interim report. Phases II and III are ongoing and are developing criteria to quantify interaction and coalescence for adjacent metal loss features, with the criteria to be evaluated relative to existing full-scale burst test data. In 2022, the project team continued finite element analysis of adjacent and nested metal loss features and started developing interaction and stacking rules for multiple metal loss features. The outcome of this effort will provide SoCalGas with a comprehensive and representative assessment of failure pressure in areas of corrosion damage.	
77	GO48	Design and Placement of Compact Service Regulators - PHMSA Cofunding (5.22.j)	20211129162053	Gas Operations	System Design & Materials		Materials and Equipment	11/19/2021	5/31/20235	$54,848	$645,629	$54,848	$0		Active		SCG $5,733 | OTD Members $59,077 | PHMSA $383,725	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	•Modification to Regulatory; Policy & Standards •Share/Publish Results	This project will review existing practices and perform comparative service regulator testing that will result in recommendations and guidance to the natural gas industry on "vent-limiting" service regulators. It will also provide additional options to natural gas utilities for the safe, outdoor installation of regulators and meter sets. This project will determine if "vent-limiting" service regulators offer more options for outdoor installation by having a smaller footprint and, thus, reduced clearance distances in comparison to traditional IRV service regulators. The project team will determine safe distance allowances through testing the quantity of gas vented during various regulator operating flow conditions and failure modes, including diaphragm ruptures. Many gas utilities have set a minimum distance to a source of ignition for both indoor and outdoor meters and regulators based on the National Fuel Gas Code's requirement. Field crews must satisfy these clearance distance requirements when installing meter set assemblies, including the regulator, on the outside of a building. These clearance distances, however, were created with standard internal relief valve regulators in mind. New "vent limiting" service regulators, typically with "slam shut" features, are now available from a few manufacturers and are being used in a limited fashion by some natural gas utilities. This project, which is co-funded by the Pipeline and Hazardous Materials Safety Administration, kicked off in November 2021. In 2022, the project team will develop the test plan; establish a Technical Advisory Committee of industry subject matter experts; identify national and international service regulators with "venting limiting" capabilities; and determine service regulators to be included in the test plan. .	
78	GO49	Digital MTR and Steel Pipe Traceability Pilot Project JIP (8.23.g)	20221121214815	Gas Operations	System Design & Materials		Tracking and Traceability of Materials	11/10/2022	11/29/2024	$30,000	$290,000	$30,000	$0		Active		SCG $30,000.00 | OTD Members $150,000.00 | JIP Members $140,000.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to conduct a pilot project with manufacturers and operators to test the process of delivering, receiving, and retrieving digital Material Test Report (MTR) data. Most steel asset manufacturers apply a barcode that contains a serial number or another identification number. Some barcodes have asset attributes such as heat number, manufacturer, grade, diameter, and wall thickness. Each manufacturer defines the content and format of these barcodes, making them non-standardized. This lack of standardization makes it difficult for operators to use the data contained in the barcode consistently. The project goal is to start the process of achieving industry adoption of recently published American Petroleum Institute Recommended Practice 5MT - Pipeline Inspection Documents for Material Traceability and Electronic Test Reports (API 5MT) for digital MTRs and Global Standards 1 (GS1) for traceability barcodes for steel pipes. The project kicked off in Q4 2022. The project team will work on developing a GS1 standard, a barcode printing kit for manufacturers and coating mills, and a digital portal to link MTR from the barcode to the portal. If the pilot project is successful, the team will propose the next steps to continue the process of achieving industry adoption. With a digitized MTR process for collecting material data and properties, SoCalGas can improve efficiency and productivity during the MTR review in the quality assurance/quality control process.	
79	GO50	Distribution System Analysis	2023090822742	Gas Operations	System Design & Materials		Pipeline Design	12/1/2023	5/31/2026	$750,000	$750,000	$0	$750,000		Active		SCG $750,000.00	Operational Efficiency, Improved Affordability, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results	This project's objective is to support future risk and threat analysis under different operating conditions by establishing families of pipes and components with specific characteristics that have similar risk profiles . The project will conduct a Critical Threat Review using a Phenomena Identification and Ranking Table (PIRT). This project will also develop an advanced probability-of-failure model by analyzing various parameters. Some of these parameters include material type, manufacturing process, prior pipeline inspection, operating histories, lab testing results, and existing probability-of-failure framework. By comparing the probability-of-failure of various pipelines, this project will help SoCalGas determine where replacements may be needed to accommodate future operations.	
80	GO51	Effect of Hydrogen Blended Natural Gas On Performance of Gas Meters and Diaphragm Type Service Regulators – Phase 1 (5.21.t)	202106230756	Gas Operations	System Design & Materials		Materials and Equipment	8/1/2021	7/31/2024	$50,757	$550,000	$50,757	$0		Active		SCG $50,757.00 | OTD Members $499,243.00	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Field Demonstration/Validation Testing; Share/Publish Results	The objective of this project is to study the effect of hydrogen-natural gas (H2-NG) blends, with up to 20% hydrogen by volume, on the durability, safety, and performance of existing gas meters and diaphragm-type service regulators commonly used for residential service. Tests include durability, accuracy, leakage rates, and oxidation induction time. The results of the research project are anticipated to aid in understanding: 1) material compatibility impacts on gas meters and regulators in H2-NG blend service; 2) impacts of H2-NG blend H2 concentration on meter accuracy; and 3) feasible H2-NG blend limits for gas meters and service regulators. In 2022, the team finalized the bill of materials for three potential testing rig options. Sponsors chose to have two rigs set up, each with nine regulators and nine meters. The team received most of the meters required for this project, while nine regulators are still needed. The project team initiated the purchasing and subcontracting activities, delivery of parts for the testing rig setup, and construction of the testing rigs through the subcontractor. Project delays were due to project rescoping and supply chain issues on parts delivery. The next step is for GTI Energy to initiate purchase orders. The construction of the rigs is expected to begin in the first quarter of 2023, and completion is expected in the second quarter. The primary project deliverable will be a final report. SoCalGas could use the results from this research to contribute to creating a statewide hydrogen injection standard.	Hydrogen-Blending Project This project will be removed from the project portfolio per Resolution or final results and ratepayer benefits will be included in the 2024 Annual Report if approved in the Tier 2 Advice Letter.
81	GO52	Effect of Upstream Piping on Ultrasonic Meter Bias (MEAS-6-5C)	2018112612	Gas Operations	System Design & Materials		Equipment Design	11/1/2018	8/27/2023	$4,971	$236,000	$4,971	$0		Completed		SCG $4,971.00 | PRCI Members $231,029.00	Reliability and Safety	Late Stage (TRL 7-9)	Technology & Knowledge Transfer/Training	The objectives of this project are to 1) assess the effect of end treatments on the velocity profile and the resulting ultrasonic meter (USM) performance, 2) develop an optimized end treatment design, and 3) evaluate the performance of a clamp-on USM in experimental testing. This project aligns with the Pipeline Research Council International (PRCI) goal to increase measurement accuracy. End treatments can cause distortions in the flow to USMs that can result in a reduction of flow meter performance and an increase in lost and unaccounted for (LAUF) gas. Currently, there are no public data for guidance or comparison of end-treatment designs. The primary benefits of this successful project are improved measurement uncertainty of USMs and reduced LAUF gas volumes from optimized end-treatment designs. The project team created computational fluid dynamics (CFD) models of six end treatments. The project team identified four end treatments for optimization and testing in 2020. Project sponsors voted to add two end treatments in optimization and testing and the collection of clamp-on USM data in the test plan in 2021. The project team started and completed experimental testing in 2022. The project team published a final report on the PRCI website for members. They will also give a webinar as the project's final presentation in early 2023. SoCalGas requested the performance testing of the new clamp-on USM model be added to the project scope to save the cost and time of conducting its evaluation. This approach allows for approved use at SoCalGas utility and customer sites.	
82	GO53	Efficacy of Offline and Online Methodologies to Measure Siloxanes in RNG (MEAS-15-04)	20210622155310	Gas Operations	System Design & Materials		Gas Composition And Quality	8/31/2021	12/31/2024	$14,603	$118,000	$14,603	$0		Active		SCG $14,603 | PRCI Members $103,397	Reliability and Safety	Late Stage (TRL 7-9)	•Modification to Regulatory; Policy & Standards •Share/Publish Results	The objective of this project is to determine the precision, accuracy, and sensitivity of the GC-IMS (Ion Mobility Spectroscopy) through the analysis of data from a second field test in partnership with OTD. GTI previously completed laboratory and field testing at a landfill site of the GC-IMS. The project team will further test an online GC-IMS siloxane sensor at a site differing in digester feedstock (such as WWTP) and geographic location from the initial tests to provide a more robust dataset. Following ASTM D8230 Standard Method for the Offline Analysis of Siloxanes in Biogas, periodic grab samples will be taken during the testing period and analyzed at laboratories. to compare the online data to offline analytical techniques. Additional renewable natural gas (RNG) pipeline specifications similar to ones in California are expected to be established. Producers, regulators, and utilities would benefit from validated and standardized measurement methodologies which meet these new, lower specifications. The ability to develop a low cost, low maintenance online analyzer capable of meeting the sensitivity and precision needs of the industry will allow suppliers to ensure near same-time compliance to regulations compared to offline analysis. .	
83	GO54	Field Test NeverWet & Other Nano-Tech Coatings to Reduce Aboveground Corrosion (5.17.p)	2017102393	Gas Operations	System Design & Materials		Materials and Equipment	9/6/2017	6/30/2023	$2,775	$217000	$2,775	$0		Completed		SCG $2,775 | OTD Members $214,225	Reliability and Safety	Mid Stage (TRL 4-6)	•Deployment of Results	This project investigates unique and promising coatings for challenging aboveground utility corrosion prevention applications. Corrosion is an ongoing threat to the integrity of metallic utility assets. For aboveground assets, one cannot rely on cathodic protection to back up coating protection. Therefore, specifying and applying the most appropriate and best-performing coating system is even more important. The unique and promising coatings that are available in the market have the potential to substantially reduce wet and dry aboveground corrosion in a wide variety of applications. Unfortunately, the NeverWet technology was discontinued, so it could not be included in the field trials. Field testing continues with three coatings being applied per the field test protocol. The project is in the planned "field exposure" phase, with the coatings logging time at their respective application sites. The plan was for the field test to include four seasons of exposure and then to assess performance. Due to COVID-19 restrictions, the field trial was extended. The extra time of exposure will benefit the meaningfulness of the assessments. To date, the applied systems continue to age in the field. .	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
84	GO55	Gas Machinery Research Council (GMRC)	20200102175422	Gas Operations	System Design & Materials		System Design	1/1/2019	12/31/2024	$20,160	$1,464,000	$20,160	$0	$3,840	Active		SCG $20,160 | GMRC Members $1,443,840	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mulitple - Program supports various projects.	•Mulitple - Program supports various projects.	With more than 70 member organizations, Gas Machinery Research Council (GMRC) is a community of natural gas companies dedicated to investigating technical issues within the rapidly evolving gas machinery industry and uncovering innovative solutions that improve the reliability, efficiency, and cost-effectiveness of mechanical and fluid systems. GMRC provides members and industry an opportunity to exchange information and ideas and participate in applied research and technology programs. GMRC accepts proposals relevant to current issues facing the gas machinery industry and seeking to improve the quality and efficiency of pipeline facilities and gas compressor stations. In 2021, GMRC active projects included: Dry Gas Seal Reliability (Phase 4), Virtual Orifice Performance Evaluation, Improvements in Elemental Sulfur Test Methods for Natural Gas, Hydrogen Blending Impacts on Compressor Stations (in partnership with Pipeline Research Council International), Hydrogen Impacts on O-Rings, and Improvements to National Institute of Standards and Technology (NIST) - Reference Fluid Thermodynamic and Transport Properties Database (RefProp) and Water-Hydrocarbon Vapor Liquid Equilibrium (VLE) Prediction (Phase 2). Three projects were completed in 2021 and results shared with members. .	
85	GO56	Gas Turbine Component Research Roadmap (CPS-5-12)	20230110232327	Gas Operations	System Design & Materials		Materials and Equipment	12/14/2022	3/31/2024	$16,912	$89,040	$8,872	$0	$5,482	Active		SCG $16,912 | PRCI Members $72,128	Reliability, Safety, and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The projective objective is to develop a roadmap to guide future PRCI research in centrifugal components for gas turbine-driven centrifugal compressors. The last roadmap was created in 2016. That research map does not reflect the current state of technology. The team will perform a literature review under this new road map and survey the current state of gas turbine-driven centrifugal compressors. They will also identify gaps that will improve gas turbine-driven compressors' safety, reliability, and performance. Once the team develops the road map, they will use it to identify and prioritize research to benefit gas utilities and the ratepayers.	
86	GO57	Guidelines for Selecting Trenchless Installation Methods (CNST-1-4)	20230418213653	Gas Operations	System Design & Materials		Construction Design	12/1/2023	4/17/2024	$9,440	$118,000	$0	$9,440		Active		SCG $9,440 | PRCI Members $108,560	Reliability and Safety	Late Stage (TRL 7-9)	Further Technology Development/Prototype; Deployment of Results; Technology & Knowledge Transfer/Training	This project's objectives are to develop a guideline outlining the currently available trenchless construction methods for pipeline installation, identifying their pros and cons, and to identify potential gaps or limitations that may lead to future trenchless technology innovation. Trenchless construction methods are used to install a pipeline around obstacles such as waterways, highways, and railroads, or to reduce potential environmental or community impacts. These methods may represent the most feasible and cost-effective option available. The project team intends to develop a guideline for the current state-of-theart trenchless construction methods based on selection criteria that include geographical formations, pipeline specifications, elevations, and depths. The guideline will include detailed information on the benefits, limits, and risks associated with each trenchless method to help determine which trenchless method may be more appropriate to utilize. SoCalGas will use the guideline for selecting, verifying, and utilizing the most appropriate and cost-effective trenchless construction methods for installing new pipelines or replacingexisting ones based on design and site conditions. This guidance should result in a safe and reliable pipeline installation, thereby minimizing environmental and community impacts that could cause disruptions in services or add additional costs to ratepayers.	
87	GO58	Hot Tap Branch Connections, JIP	20191210173947	Gas Operations	System Design & Materials		System Design	12/16/2019	9/20/2023	$30,000	$1,050,000	$30,000	$0		Completed		SCG $30,000.00 | JIP Members $1,020,000.00	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Modifications to Regulatory, Policy & Standards, Share/Publish Results; Technology & Knowledge Transfer/Training	Hot tap branch connections have long been an important aspect of pipeline and piping system operations. This joint industry project (JIP) aims to develop industry best practices for welding stub-on branch connections onto live gas mains (i.e., hot taps) and to provide a guideline that enables the least-complicated procedure to be selected for a given application. Developing and using industry best practices for specifying and installing hot tap branch connections will reduce costs and increase safety and reliability. Previously, the team completed a report on in-service failures and guidance on fitting types and weld spacing. In 2022, the team completed the final version of the PRCI Pipeline Repair Manual. Additionally, revisions were made to the 22nd edition of API 1104, which is a global standard that supports industry-wide requirements for gas and arc welding used in the construction and in-service repair of pipes to improve pipeline safety, structural integrity, and efficiency by providing detailed welding procedures for qualified professional welders, inspectors, and engineers. The project team continues to work on qualifying procedures using a mechanized system for in-service welding, which can make longitudinal seam welds and circumferential fillet welds. The results of this JIP may aid SoCalGas in identifying instances where in-service welding may be acceptable or prohibited. It could also allow it to realize significant economic and environmental benefits.	
88	GO59	HyBlend Collaborative Research Partnership (5.21.k)	2021062301611	Gas Operations	System Design & Materials		System Design	9/1/2021	9/28/2024	$50,000	$15,050,000	$50,000	$0		Active		SCG $50,000 | OTD Members: $4,100,000 | DOE: $10,900,000	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mulitple - Program supports various projects.	•Mulitple - Program supports various projects.	Begun in August 2021, the HyBlend Project is a joint effort of national labs, natural gas operators, and research consortia to evaluate technical and economic considerations associated with transporting hydrogen blends and other low-carbon fuels using existing gas infrastructure. The project team is addressing many topics related to hydrogen blending, including hydrogen compatibility with metals and polymers, life cycle analysis, techno-economic analysis, and building equipment. Five national labs will lead the research. Sandia National Laboratory will lead development of general pipeline integrity guidance for operating natural gas transmission and distribution systems with hydrogen blends by assessing the role of these blends in the degradation of metal pipelines. Pacific Northwest National Laboratory will lead the assessment of hydrogen blends on the degradation of polymer pipelines and material lifespan. Argonne National Laboratory will lead the life cycle analysis of technology pathways for hydrogen blends. The National Renewable Energy Laboratory will lead the quantification of costs and opportunities for hydrogen production and blending within the natural gas system. Oak Ridge National Laboratory will lead the evaluation of residential, commercial, and industrial end uses with hydrogen blends, assessing safety, emissions, reliability, and energy efficiency. In 2021, the team began establishing test conditions and materials and working on a literature review of global research and experience in operating natural gas pipeline systems with hydrogen blends. The team will publish a compilation of reports and white papers at project completion. SoCalGas will use these results to support the development of a hydrogen blending standard and to guide future research. .	Hydrogen-Blending Project This project will be removed from the project portfolio per Resolution or final results and ratepayer benefits will be included in the 2024 Annual Report if approved in the Tier 2 Advice Letter.
89	GO60	Hydrogen Blending Impact on Aldyl-A and HDPE Pipes (5.21.j)	2021070217132	Gas Operations	System Design & Materials		Materials and Equipment	4/8/2021	3/31/2024	$493,503	$952,403	$493,503	$0		Active		SCG $493,03.00 | OTD Members $458,900.00	Reliability and Safety	Late Stage (TRL 7-9)	New Research Project to Advance TRL; Field Demonstration/Validation Testing	This project will develop a lifetime-prediction and associated risk model for Aldyl-A and vintage High-Density Polyethylene (HDPE) pipes pressurized with a blend of natural gas and hydrogen. SoCalGas is interested in understanding how the interaction between hydrogen and chemical additives in the resin could lead to chemical degradation and lower resistance to slow crack growth. It is also of interest to understand the physical interaction of hydrogen and materials at the crack tip of micro-fractures leading to accelerated crack growth. It is crucial to understand the impact of hydrogen blends on the existing PE infrastructure to maintain the integrity and safety of gas distribution pipelines. Risk impact due to hydrogen blending must be quantified so operating procedures and associated budgets can be adjusted accordingly. Long-term strength tests, tensile tests, and several material tests will be performed to observe the material's behavior in the hydrogen/natural gas blend and to develop the lifetime prediction and risk models. Aldyl-A and HDPE Pipe samples have been collected, and the Oxidation Induction Time, Cross-Polarized Light Microscopy, and Tensile tests have been completed. The construction and shakedown of the testing apparatus for the Long-Term Hydrostatic Strength tests took some time due to resource issues, which delayed the tests. Testing of Aldyl-A samples has been completed. HDPE testing is planned for the beginning of 2023.	Hydrogen-Blending Project This project will be removed from the project portfolio per Resolution or final results and ratepayer benefits will be included in the 2024 Annual Report if approved in the Tier 2 Advice Letter.
90	GO61	Hydrogen Embrittlement and Crack Growth (Phase 2)	20200720173851	Gas Operations	System Design & Materials		Gas Composition And Quality	12/15/2020	5/31/2023	$285,466	$285,466	$285,466	$0		Completed		SCG $285,466.00 | None $0.00	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results	The project objective is to characterize the Fatigue Crack Growth Rate (FCGR) behavior of different steel pipe grades in a range of hydrogen-natural gas blends. The team will determine the FCGR for base metals, longitudinal seam welds, and girth welds at both the weld center line and Heat-Affected Zone (HAZ). Each phase or subphase will test one pipe grade: Phase 1a (X70), Phase 1b (X52 and X65), and Phase 2 (vintage X42 and X52). In 2021, the project team completed Phase 1a. The results showed that the FCGR accelerated for the various microstructures in the environments (i.e., hydrogen blends) caused by hydrogen embrittlement mechanisms. This finding expanded the project's scope to include testing for microstructural characterization since defects in microstructure strongly influence crack initiation processes. The team performed a complementary microscopy study for new API X65 steel samples. In 2022, the project team completed the testing for Phase 1b, the microscopy study, and Phase 2. The new X52 testing baseline results of the base metal showed similar trends as X70 and X65 pipes. The team delivered the final report for Phase 1B in December 2022, and they expect the final reports for the microscopy study and Phase 2 in January 2023. SoCalGas will use this knowledge to understand the effects of hydrogen embrittlement on steel pipes and to direct additional research.	Hydrogen-Blending Project The project was completed prior to Resolution.
91	GO62	Identification and Development of an Analyzer for Siloxane Measurement (M2018-010) Ph II	20200630211156	Gas Operations	System Design & Materials		Gas Composition And Quality	1/31/2021	1/31/2023	$28,940	$256,203	$28,940	$0		Completed		SCG $28,940.00 | NYSEARCH Members $227,263.00	Reliability and Safety	Mid Stage (TRL 4-6)	Further Technology Development/Prototype; Technology & Knowledge Transfer/Training;	The overall goal of this project was to find a robust measurement method that could detect Siloxanes in renewable natural gas (RNG). Siloxanes are man-made organic compounds that contain silicon, oxygen, and methyl groups. Silicon compounds are commonly found in personal hygiene, health care, and industrial products leading to the formation of siloxane in biomethane produced from the anaerobic digestion of waste from landfills and wastewater treatment plants. Combustion of renewable natural gas (RNG) containing siloxanes produces a silica deposit on downstream surfaces that can impact the safety and reliability of appliances and the efficiency of industrial equipment. The Phase II objective was to identify a suitable portable technology that can measure low levels of siloxane concentrations (~0.1 mg Si/m3) and to test the instrument in a wide range of applications. Previously, in phase I of this project, the team evaluated analyzers in the laboratory and the field to provide the technology options for Phase II. During phase II, the team gathered data and information on the presence of siloxanes in RNG that can be used to develop a standard on acceptable siloxane levels. The team chose five analyzers, and testing was conducted for accuracy and reproducibility using the new American Society for Testing and Materials standard. An interim report of the results will help funders determine the analyzer(s) to be evaluated in the next step during field testing.	
92	GO63	Impact of Blended H2 on Threaded Connections (M2021-007)	20210810214230	Gas Operations	System Design & Materials		System Design	8/9/2021	3/31/2023	$19,011	$213,092	$19,011	$0		Completed		SCG $19,011 | NYSEARCH Members $194,081	Reliability, Safety, and Environmental: Reduced GHG Emissions	Early Stage (TRL1-3)	•New Research Project to Advance TRL Level •Modification to Regulatory; Policy & Standards •Share/Publish Results	The objective of this project is to determine if hydrogen blends in natural gas cause any change in 1) the presence or absence of leaks and 2) the leak flow rate for threaded connections. This project consists of four tasks involving threaded connections that conform to National Pipe Thread (NPT) standards. In Task 1, the team is developing test protocols and determining the test sample size. Tasks 2 and 3 includes tests to determine the change in a leak or leak flow rate with a 20% hydrogen blend. In Task 4, the project team will determine the impact of various pipe dope and sealants and if hydrogen blends influence this variable. The team will also perform tests on non-NPT threaded connections. The project kicked off in October 2021 establishing procedures for creating threaded connection leaks and methods to measure leak flow rates with hydrogen blends. SoCalGas will use this data to support the determination of a hydrogen blend limit for natural gas distribution systems that will contribute to a statewide hydrogen injection standard. .	Hydrogen-Blending Project The project was completed prior to Resolution.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
93	GO64	Impact of Hydrogen/Natural Gas Blends on LDC Infrastructure Integrity (M2020-002 PhII)	2020052652138	Gas Operations	System Design & Materials		Gas Composition And Quality	4/22/2021	6/30/2023	$31,910	$425,024	$31,910	$0		Completed		SCG $31,910 | NYSEARCH Members $393,114	Reliability and Safety	Mid Stage (TRL 4-6)	•New Research Project to Advance TRL Level •Modification to Regulatory, Policy, Standards	The objective of this project is to determine if blending hydrogen into natural gas will change the physical properties of elastomers in a natural gas delivery system, the most common of which are styrene-butadiene rubber (SBR) and acrylonitrile butadiene rubber (NBR). Both are used as seals in compression applications and as gaskets for flanges in joining pipes and fittings. The lack of data on the effect of hydrogen concentrations in hydrogen/natural gas blends on elastomers in a natural gas infrastructure (e.g., piping, piping components, and appurtenances) may impact the safety and reliability of the gas delivery system. In Phase 1, the team performed exploratory tests using a limited set of test gas mixtures. Phase 2 will involve further tests on field-extracted and virgin materials using an expanded set of test gases. The team completed Phase 1 in April 2021 with a preliminary assessment of the impact of varying hydrogen concentrations in methane/hydrogen blends on the mechanical and physical properties of SBR and NBR elastomers in common use as coupling materials used to join metal pipes. Results from Phase 1 found that unrestrained SBR cubes exhibited a change during creep tests with a dimensional change and a reduction in elasticity. Phase 2 will leverage findings from Phase 1 and test new and vintage materials with a wide range of hydrogen blends (up to 20%), pressures, and temperatures. To date, the team has completed stress relaxation analysis for NBR and SBR materials at 5% hydrogen. The next step is to evaluate 20% hydrogen blends and constant load performance. This project will help SoCalGas determine if and how hydrogen blends will affect the physical properties of typical elastomers and the hydrogen blend level that the existing natural gas system can tolerate. .	Hydrogen-Blending Project The project was completed prior to Resolution.
94	GO65	Implementing API 5L RP 5MT, "Pipeline Inspection Documents for Material Traceability and Electronic Test Reports " (8.22.c)	20220114185642	Gas Operations	System Design & Materials		Materials and Equipment	3/1/2022	5/30/2024	$13,831	$255,000	$13,831	$0		Active		SCG $13,831 | OTD Members $241,169	Reliability, Safety, Operational Efficiency, and Improved Affordability	Early Stage (TRL 1-3)	•Modification to Regulatory; Policy & Standards •Deployment of Results	American Petroleum Institute (API) Standard 5L is the standard for transmission pipes used in the natural gas and petroleum industries. This standard governs specifications for seamless and welded steel pipes of different grades. These specifications are validated with tests, and the results are published in a specification report for each type of steel and grade. Suppliers currently provide their reports in paper form. The goal of this project is to develop an electronic form of the report for manufacturers to use. The team will develop a digital template to make the report available to customers electronically. A common standard for electronic reports streamlines industry efforts. The project will also develop a method for verification that the report is from the manufacturer of the pipe. This will improve traceability by providing an electronic signature that ties the test report directly to the manufacturer. .	
95	GO66	Individual Packaging Requirement for all Bulk Packaged Plastic Fittings (5.24.g)	20240104172619	Gas Operations	System Design & Materials		Materials and Equipment - Pipes & Fittings	12/1/2023	6/1/2025	$83,083	$152,000	$0	$83,083		Active		SCG $83,083 | OTD Members $68,917	Operational Efficiency, and Improved Affordability	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results	The objectives of this project are to develop the requirements for individual packaging of plastic fittings and incorporate the requirements in the applicable American Society of Testing and Materials (ASTM) standards. Joining polyethylene (PE) pipe is a fundamental activity performed by every gas utility across the country. Utilities are seeking to enhance the integrity of PE fusions. Although the failure rate for PE fusions is quite low, the consequences of these limited failures can be significant. Pipe and fitting contamination is one of the leading causes of joint integrity issues. Currently, there is no mandatory requirement or guidance for plastic fittings to be packaged individually when they are provided in "bulk" packaging. This can result in potential contamination or dislodged and/or missing components such as O-rings or fasteners. Requiring individual packaging of all products will improve overall system integrity by reducing the risk of fitting contamination and/or displaced fitting components. The team will work with the project sponsors to identify the ASTM standard(s) to update, create the appropriate packaging language to require individual component packaging when bulk packaging is used, and work to incorporate this new natural gas industry language into the appropriate ASTM standards. This project will improve the integrity of SoCalGas' plastic piping systems by minimizing or eliminating the risk of using potentially contaminated fittings during installations. It would also prevent or minimize the operations cost associated with repairing leaks due to contaminated joints.	
96	GO67	Integrity Impact of HAZ Softening on Type-B Sleeves and Hot Tap on Modern Steel (SBD-1-6A)	2021101422849	Gas Operations	System Design & Materials		System Design	10/13/2021	10/13/2023	$13,587	$177,000	$13,587	$0		Completed		SCG $13,587 | PRCI Members $163,413	Reliability and Safety	Early Stage (TRL 1-3)	•Field Demonstration/Validation Testing	Heat Affected Zone (HAZ) softening occurs in girth welds on pipelines. The HAZ area loses mechanical strength which creates a mismatch between mechanical properties of the pipe and the HAZ. Girth welds are not only used in pipeline construction but are also used in some pipeline repairs. Type-B sleeves are one such repair type. The sleeve is welded to the pipeline to repair leaks and damaged section of the pipeline. HAZ also occurs in another repair method -hot taps. This project investigates HAZ softening in Type-B sleeves and hot taps in pipeline repairs. Tests will be performed to test different welding and installation procedures to minimize the loss of mechanical strength in HAZ. A final report will be delivered with recommended welding and installation procedures for using Type-B sleeves and hot taps. This project will enhance pipeline integrity by minimizing pipeline failures. .	
97	GO68	LUAF Study	2023082323286	Gas Operations	System Design & Materials		Materials and Equipment	12/1/2023	3/31/2024	$70,975	$70,975	$0	$70,975		Active		SCG $70,975.00 | None $0.00	Reliability,Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	The objective of this project is to characterize and estimate the measurement- and theft-related variables for lost and unaccounted-for (LUAF) gas volumes on the SoCalGas delivery system. The original SoCalGas study on determining LUAF gas volumes was developed by the Gas Research Institute in the early 1990's (GRI report 93/0115). An update to the report looking specifically at the measurement factor was conducted in 2006 by SoCalGas . Since then, equipment and operating practices have changed greatly, especially with the introduction of new technology. Historically, measurement has accounted for the greatest percentage of SoCalGas LUAF. However, the contribution of natural gas theft to LUAF estimates has been difficult to define; it is known that new methods of theft have been identified in recent years. This project will perform a detailed analysis of 1) the metering technology and components within SoCalGas for 2018-2022, and 2) the main areas of annual variability, identifying the factors and variables that affect SoCalGas customer service and theft-related distribution LUAF. The project deliverables will include two final reports: measurement-related LUAF and theft-related LUAF. Each report will include recommendations for future consideration (if warranted). The knowledge gained from the results will be used to provide recommendations for ways to make SoCalGas systems more efficient. If the results precisely identify the current contribution of the measurement and theft components of LUAF and identify the ways to reduce measurement and theft LUAF in the future, then SoCalGas would implement the identified areas of improvement.	
98	GO69	Managing Stress From Uneven Support & Settlement (CNST-2-2A)	2022042722280	Gas Operations	System Design & Materials		System Design	3/25/2022	3/25/2024	$15,234	$188,000	$15,234	$0		Active		SCG $15,234 | PRCI Members $172,766	Reliability and Safety	Mid Stage (TRL 4-6)	•Deployment of Results •Share/Publish Results	The objective of this project is to develop guidelines and procedures to manage strain and stress from uneven support and soil settlement in the design, construction, and maintenance of pipelines. High strain and stress could lead to fractures in pipelines causing failures and disruption to services for ratepayers. This project will investigate current practices of utilities to address external strain and stress. The project team plans to investigate excavation and backfill practices that cause high strain and stress by gathering utility data for analysis. The team also plans to delve deeper into the subject by covering terrain conditions that may contribute to higher strain and stress. Model simulations will be used to simulate and quantify the strain and stress to develop best practices to minimize strain and stress on pipelines. In addition to delivering the guideline and procedure for best practices, the project team will hold a workshop to train utilities on how to implement the best practices to minimize strain and stress on pipelines. The outcome of this project will lead to better integrity management of gas pipelines to prevent failures from uneven support and settlement of pipelines, making the pipeline system safer and more resilient. SoCalGas supported this project in anticipation that the guidelines and procedures for best practices could improve design, construction, and maintenance to minimize strain and stress on its pipelines. .	
99	GO70	MAOP and Materials Verification - Phase I (4.17.d)	2017092812	Gas Operations	System Design & Materials		Tracking and Traceability of Materials	9/8/2017	2/28/2023	$11,364	$116,000	$11,364	$0		Completed		SCG $4,364.00 | OTD Members $91,636.00	Reliability and Safety	Mid Stage (TRL 4-6)	Technology & Knowledge Transfer/Training	The project objective is to provide software tools to assist operators in complying with the maximum allowable operating pressure (MAOP) and materials verification requirements in the proposed rule on the Integrity Verification Process (IVP). The proposed guideline allows using Engineering Critical Assessments (ECA) instead of a hydrotest, derating, or pipe replacement. The pending rule also allows pipe surface-based non-destructive measurements instead of cutouts and reduces the number of destructive tests. The team has developed a set of models using the ASME B31G-modified (wall loss defects) and the Maxey-Folias Leak-Rupture Boundary model and shared them with the Specified Maximum Yield Stress Boundary Project. The design work continues with the development of modules for the ECA tools. The project team has also identified a new compiler/computer language to replace Fortran/Ruby language-based tools and improve computer performance for new and existing models. The project team has made significant progress in importing the ten-million-point dataset and using it in model calculations with resulting output in spreadsheet format. The team plans to continue the development of additional modules for the ECA tools. Project deliverables will include the developed modules along with a final report. SoCalGas could use this tool to comply with the proposed IVP Rule.	
100	GO71	Microstructural Characterization of Pipe Steels Exposed to Hydrogen Blends	202105287156	Gas Operations	System Design & Materials		Gas Composition And Quality	5/1/2021	5/31/2023	$78,500	$78,500	$78,500	$0		Completed		SCG $78,500.00 | None $0.00	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results	The project objective is to characterize the Fatigue Crack Growth Rate (FCGR) behavior of different steel pipe grades in a range of hydrogen-natural gas blends. The team will determine the FCGR for base metals, longitudinal seam welds, and girth welds at both the weld center line and Heat-Affected Zone (HAZ). Each phase or subphase will test one pipe grade: Phase 1a (X70), Phase 1b (X52 and X65), and Phase 2 (vintage X42 and X52). In 2021, the project team completed Phase 1a. The results showed that the FCGR accelerated for the various microstructures in the environments (i.e., hydrogen blends) caused by hydrogen embrittlement mechanisms. This finding expanded the project's scope to include testing for microstructural characterization since defects in microstructure strongly influence crack initiation processes. The team performed a complementary microscopy study for new API X65 steel samples. In 2022, the project team completed the testing for Phase 1b, the microscopy study, and Phase 2. The new X52 testing baseline results of the base metal showed similar trends as X70 and X65 pipes. The team delivered the final report for Phase 1B in December 2022, and they expect the final reports for the microscopy study and Phase 2 in January 2023. SoCalGas will use this knowledge to understand the effects of hydrogen embrittlement on steel pipes and to direct additional research.	Hydrogen-Blending Project The project was completed prior to Resolution.
101	GO72	Multi-Compound Green Corrosion Inhibitor for Gas Pipeline	20240110234318	Gas Operations	System Design & Materials		Corrosion System Design	12/1/2023	9/29/2026	$4,000	$1,004,000	$0	$4,000		Active		SCG $4000 | PHMSA $1,000,000	Reliability, Safety, Operational Efficiency	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this Pipeline and Hazardous Material Safety Administration co-funded project is to develop a novel "green" corrosion inhibitor, optimize its implementation in gas pipeline environments, and evaluate the inhibitor's effectiveness and compatibility through laboratory testing and nondestructive evaluation measurements. Compared to traditional chemical inhibitors, green corrosion inhibitors may offer great potential to mitigate internal corrosion, while being environmentally friendly. This project will evaluate and test multi-compound green inhibitors derived from renewable feedstocks for performance. The project team will simulate the implementation to recommend best practices for different pipe geometries, inhibitor properties, and operational factors. Validation testing will include inhibitor coating thickness, gas properties, and pipeline properties. In 2023, the project team worked on the design and synthesis of green inhibitors and explored potential candidates for green corrosion inhibitors suitable for gas pipeline protection. The next step is to develop the test protocols. SoCalGas anticipates using environmentally friendly alternatives to prevent corrosion in pipelines. The research could help identify features for Integrity Management, which will benefit ratepayers by improving operational efficiencyand safety, while reducing the environmental impact of using corrosion inhibitors to protect the pipelines.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
102	GO73	On-Line Biomethane Gas Quality Monitoring Ph III (7.16.e.3)	2021062301148	Gas Operations	System Design & Materials		Gas Composition And Quality	8/1/2021	12/31/2024	$56,439	$267,000	$56,439	$0		Active		SCG $56,439 | OTD Members $210,561	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	•Field Demonstration/Validation Testing •Share/Publish Results	In past phases of this project, validation testing on several on-line biomethane analyzers were performed to identify which would have the potential to detect unconventional trace constituents. Two analyzers were proposed for consideration for further development under Phase 3. The goal of Phase 3 is to perform product development on the selected analyzer and to test the modified analyzer to validate the monitoring of the unconventional trace contaminants. These trace constituents are sometimes found in biomethane if cleanup technologies fail. These unconventional trace constituents are not routinely monitored by on-line instruments but are critical to gas quality. Utilities need technologies to provide real-time gas quality data for these trace constituents. In this phase, the analyzer manufacturer will work to modify their system to incorporate changes identified in Phase II with the goal of commercializing the analyzer. The newly developed on-line analyzer will be tested with continuous gas streams compared to laboratory measurements following standard methods to evaluate precision, accuracy, and operational experience. The deliverable will be a market-ready analyzer, available for field tests, which can monitor the predominant species of ethylbenzene, toluene, siloxanes, organic arsenics, halogenated hydrocarbons, and n-nitroso-di-n-propylamine. Once available, this analyzer could be installed at locations where there is a potential for trace constituents above the limits. The project kick-off meeting was held in November 2021, and sponsors discussed which analyzer should be developed further after reviewing data on cost and maintainability. The next step is to finalize the analyzer selection. .	
103	GO74	Optimize the Detection and Mitigation of Mechanical Damage (SRP-MD-01)	20210720171815	Gas Operations	System Design & Materials		Materials and Equipment	1/1/2021	12/31/202~~3~~4	$75,000	$2,042,507	$49,040	$25,960		Active		SCG $75,000 | PRCI Members $1,967,507	Reliability and Safety	Mulitple - Program supports various projects.	•Mulitple - Program supports various projects.	Detecting and mitigating mechanical damage to pipeline infrastructure is a major concern to the natural gas industry. The Pipeline Research Council International established this Strategic Research Priority (SRP) to coordinate the efforts across all technical committees (Compressor Pump Station, Design Materials Construction, Surveillance Operations Monitoring, Measurement and Underground Storage). The SRP goal is to provide a roadmap of research projects to close the gaps on mechanical damage (MD) research and to produce a comprehensive set of guidelines and tools for managing the threat of MD. The SRP funded one project in 2021: Analysis of Pipeline Operator and Prior R&D Data (MD-2-5). An additional SRP project will be added in 2022: Improvements to Mechanical Damage Engineering Assessment Tool (MD-2-4). .	
104	GO75	Pathway to Achieving Efficient and Effective Crack Management (SRP-CM-01)	2021072171434	Gas Operations	System Design & Materials		Materials and Equipment	1/1/2021	12/31/202~~3~~4	$75,000	$5,193,400	$73,095	$1,905		Active		SCG $75,000 | PRCI Members $5,118,400	Reliability and Safety	Mulitple - Program supports various projects.	•Mulitple - Program supports various projects.	This research intends to advance critical areas associated with the execution of crack management programs that eliminate crack-related failures. The Pipeline Research Council International established this strategic research priority (SRP) to coordinate efforts across all the technical committees (Compressor Pump Station, Design Materials Construction, Surveillance Operations Monitoring, Measurement, and Underground Storage). The goal of the SRP is to provide a roadmap of research projects to further understand and efficiently and effectively manage cracks in pipelines. Research will focus on four core areas: susceptibility, inspection, management, and assessment and remediation. The SRP funded two projects in 2021: Understanding Why Cracks Fail (MAT-8-3), and Improvement of ILI Capabilities Joint Industry Project (PHASE II) (NDE-4-12). .	
105	GO76	Pipeline Integrity Tool Cloud Based Assessment Software Consortium Project (MAT-8A/JCAS-01)	20200116212934	Gas Operations	System Design & Materials		System Design	9/1/2019	12/31/2024	$67,645	$621,695	$67,645	$0		Active		SCG $67,645.00 | PRCI Members $554,050.00	Reliability, Safety, and Improved Affordability	Late Stage (TRL 7-9)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing; Deployment of Results; Technology & Knowledge Transfer/Training;	The objectives of this joint industry project (JIP) are to develop an improved model for pipeline seam weld anomalies and to improve the existing Pipeline Research Council International (PRCI) MAT-8A fracture mechanics model and its input parameters. The final product will be a cloud-based software that uses probabilistic fracture mechanics (PFM) with the updated MAT-8 model. The new software enables operators to optimize resources by evaluating different mitigation scenarios. In 2022, the project team conducted training sessions for sponsors on fracture mechanics, probability concepts, and the cloud-based software. Evaluation of the methodology to analyze populations of non-detected defects against PRCI methodology is ongoing. At the conclusion of this project, a report and updated model in the form of cloud-based software will be delivered to the project participants. SoCalGas will use these results to make informed decisions when conducting Engineering Critical Analysis (ECA) for various applications such as general fitness for service, maximum allowable operating pressure reconfirmation, and In-Line Inspection (ILI) tool validation. The anticipated development of an analysis methodology for undetected populations of cracks in pipelines could assist SoCalGas in performing this type of analysis for ECA without ILI to support regulatory requirements because of the Gas Transmission Safety Rule.	
106	GO77	Practical Girth Weld Evaluation Criteria Considering Weld Strength Mismatch and HAZ Softening (MATH-5-3D)	20211013141320	Gas Operations	System Design & Materials		System Design	10/5/2021	5/31/2024	$14,350	$212,400	$14,350	$0		Active		SCG $14,350 | PRCI Members $198,050	Reliability and Safety	Mid Stage (TRL 4-6)	•Modification to Regulatory; Policy & Standards •Share/Publish Results	This project continues work from previous girth weld research projects for which new testing methods and welding guidance documents were developed (MATH-5-3B and MATH-5-3C.) This project uses these results to propose revisions to current welding standards - the American Petroleum Standard 1104 and Canadian Standard Association Z662- to address girth weld strength mismatch. These revisions will improve pipeline integrity, safety, and reliability of pipelines by updating the standards with new testing methods and new procedures for minimizing heat affected zone (HAZ) softening near girth welds to prevent strength mismatch. .	
107	GO78	PRCI Emerging Fuels Institute	20210824201539	Gas Operations	System Design & Materials		Gas Composition And Quality	6/15/2021	12/31/2026	$750,000	$5,475,000	$750,000	$0	$250,000	Active		SCG $675,000.00 | PRCI Members $4,800,000.00	Reliability, Safety, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Multiple - Program supports various projects.	Multiple - Program supports various projects.	Pipeline Research Council International (PRCI) established the Emerging Fuels Institute (EFI) in April 2021 to address the challenges of transitioning to clean fuels. The EFI will focus on infrastructure related to various emerging fuels, such as renewable natural gas (RNG), ammonia, and biofuels. The EFI focuses on the following areas: pipeline system integrity; steel and non-steel components; compressor stations, pressure control, and over-pressure safety devices; electrical classification and fire safety; and underground storage. In 2023, the EFI funded several new projects, which included: EFI Guidance Document (JEFI-00-02); Emerging Fuel Measurement (JEFI-02-03); B31.4, B31.8, B31.12, and Emerging Fuels Discussion (JEFI-04-10); the Department of Energy's SHASTA Program (JEFI-05-02); and Implement Fiber Optic Technology for Underground Gas Storage Well Monitoring, a Pipeline and Hazardous Materials Safety Administration project. Additionally, work continues on the following previously funded projects: RNG Trace Components Database (EFI-02-01); NewGasMet/PRCI Collaboration; and EFI Talking Points (EFI-00-01). Participation in the EFI enhances SoCalGas' knowledge and expands its knowledge library to assist in improving the safety of its pipeline network infrastructure.	
108	GO79	PRCI Guidance Document for the Twenty-Second Edition of API 1104 (API 1-2B)	20230911161744	Gas Operations	System Design & Materials		Equipment Design	12/1/2023	5/2/2024	$9,963	$241,900	$0	$9,963		Active		SCG $9,963 | PRCI Members $231,937	Reliability, Safety, Improved Affordability	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results	The objective of this project is to update the Pipeline Research Council International guidance document for the Twenty-second Edition of American Petroleum Institute (API) Standard 1104 – Welding of Pipelines and Related Facilities (API 1104). The development of the updated guidance document will enable both users and regulators to better understand the intent regarding the interpretation and rationale behind the requirements. The use of this updated guidance document will increase the safety and reliability of newly constructed pipelines by helping avoid misinterpretation of requirements. It will also enable users to confidently tailor welding procedures to better fit the requirements of their specific needs within the bounds of API 1104. This may, in turn, reduce the cost of pipeline construction and maintenance activities. The milestone deliverables include: 1) outline of guidance to address industry needs, 2) outline of guidance required for the Twenty-second Edition, and 3) summarizing the changes between the Twenty-first and Twenty-second Editions of API 1104. In 2023, the project team developed an outline to address industry needs for the Twenty-second Edition and compiled a summary of the changes between the Twenty-first and Twenty-second. Anticipated ratepayer benefits include integrity, safety, reliability, and improving affordability through cost reductions. SoCalGas will deploy these results to update its existing welding procedures that reference API 1104.	
109	GO80	Product Standards for Plastic Tapping Tees (5.24.f)	20240104171815	Gas Operations	System Design & Materials		Materials and Equipment - Pipes & Fittings	12/1/2023	12/1/2025	$66,000	$220,000	$0	$66,000		Active		SCG $66,000 | OTD Members $154,000	Operational Efficiency, and Improved Affordability	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results	The objective of this project is to develop a draft product standard document for tapping tees. The developed draft product standards can be used by operators for purchasing specifications and may be used to develop American Society of Testing and Materials (ASTM) standards. Currently there are no defined product standards that manufactured tapping tees must meet. There is a standard for the tees to ensure a certain level of joint integrity, but not for the plastic tee fitting itself. The materials used and the overall design and dimensions of these tapping tees can impact the performance of these fittings. History has shown that improper selection of materials or poor fitting designs can lead to premature failure of the fitting. Creating a product standard for conventional heat fusion tees will ensure that the tees uphold certain standards for fitting quality and performance. There are a lot of variables that need to be considered regarding how tapping tee fittings are designed, manufactured, and tested. The project aims to create a task team to develop specifications for tapping tees. The specifications will include overall design, dimensions, and geometrical considerations, and fitting component requirements. The project team will identify all the design criteria and determine what stresses the components are designed for, establish the types of failure for each component, and aim to design out the issue that could ultimately lead to failure. The project will develop a test protocol for each component and testing will be carried out per industry and consensus standards to determine if they meet a specific performance requirement. This project will help SoCalGas in review of their material specification requirements for tapping tees.	
110	GO81	Reserve Strain Capacity Determination	20221027175356	Gas Operations	System Design & Materials		Materials and Equipment	3/30/2022	10/30/2024	$2,500	$1,936,008	$600	$1,900	$100	Active		SCG $2,500.00 | OTD Members $496,000.00 | PHMSA $1437,508.00	Reliability and Safety	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Modification to Regulatory Policy & Standards; Share/Publish Results; Technology & Knowledge Transfer/Training	This project aims to develop a model for measuring accumulated strain on existing pipelines. The team will accomplish this by developing and demonstrating a model network for predictive modeling with decision nodes to show a decision path's outcome (diagrams). The project will also employ the following: 1) scenario analysis for strain interventions, 2) satellite-based ground movement data, 3) causal models for pipeline modes of failures, and 4) metallurgical influences on pipeline properties, which are all required to develop a model to measure accumulated pipeline strains. Satellite data can be used to assess the strains on existing pipes. Metallurgical influences can help reveal the behavior of the steel pipeline and damage propagation in the steel under interacting threats. This Pipeline and Hazardous Materials Safety Administration (PHMSA) co-funded project will provide the necessary modeling and data analysis framework to correlate satellite-based ground movement data to strains on pipelines of interest. In 2022, the project team identified potential sites where satellite and standard data correlate with pipe movement and strain measurement. The development of causal models for multiple pipeline modes of failure and the identification of metallurgical influences on pipeline properties are ongoing. The initial modeling feedback gave the team further insight to focus on a more complete and robust collection of modeling parameters and approaches. SoCalGas intends to use the model as a guide to determine the amount of strain on a pipeline due to ground movement.	
111	GO82	Review and Evaluation of the Utonomy Smart Regulator, Phase 2 (5.19.k.2)	20200113225859	Gas Operations	System Design & Materials		Materials and Equipment	1/31/2021	1/31/2024	$76,644	$291,800	$76,644	$0		Active		SCG $76,644 | OTD Members $215,156	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	•Share/Publish Results •Technlogy & Knowledge Transfer/Training	The objective of this project is to demonstrate the operation and benefits of the Utonomy Smart Regulator (USR) through laboratory testing and field trials. The use of the USR could provide operators with the ability to remotely monitor and control district regulator stations. The project includes both laboratory and field testing with Utonomy as a partner. In 2021, the task of documenting the Products and System Needs Validation and Requirements began. The next steps are to complete the requirements documentation and perform tests at the Fisher Flow Laboratory. An interim report will be prepared after the laboratory testing is complete to determine whether the project should move forward with field trials. This project has potential technical links to company efforts to bring remote monitoring and control to our distribution system. Further, it aligns with the recently published Pipeline and Hazardous Materials Safety Administration Advisory Bulletin titled Pipeline Safety: Overpressure Protection on Low-Pressure Natural Gas Distribution Systems [Docket No. PHMSA–2020–0025]. .	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
112	GO83	Revision of the PRCI Hot-tap Model Two Different Base Material (MATR-3-1B)	20201015223439	Gas Operations	System Design & Materials		System Design	8/17/2020	3/31/2024	$19,946	$69,620	$19,946	$0		Active		SCG $19,946.00 | PRCI Members $49,674.00	Reliability and Safety	Mid Stage (TRL 4-6)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to complete the development of the Pipeline Research Council International's (PRCI) Hot Tap Model V5, a thermal analysis model for in-service welding. This project will update version 4.2.1 of the model and software to expand its coverage to include welding of two different materials and to meet current technology standards. Modeling two kinds of metal could enable a clear understanding of the cooling aspect of the different materials. The project team has updated the model and incorporated it into the software. Although the team completed programming during testing, they encountered issues with the software's graphical user interface (GUI). The team is actively working on the challenges, and progress continues. Unfortunately, the GUI issue has delayed project completion, scheduled to be completed in 2022, to the first quarter of 2023. Once the team finishes the GUI, the Hot Tap Model V5 will be available to PRCI members. The updated software will allow SoCalGas and other utilities to predict weld properties better, thereby enhancing the safety and reliability of pipelines.	
113	GO84	RNG Blending Skid Study	2023011114435	Gas Operations	System Design & Materials		Materials and Equipment	11/17/2022	2/28/2025	$400,000	$400,000	$149,032	$250,968	$149,032	Active		SCG $400,000.00 | None $0.00	Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop a process and skid design supporting new renewable natural gas (RNG) Interconnections in achieving pipeline gas quality specifications per SoCalGas Rule 45. This effort intends to perform a field demonstration to qualify RNG blending equipment and configurations that will 1) meet Rule 45 requirements, 2) maintain existing pipeline integrity requirements, 3) mitigate the risk of allowing substandard gas from entering the pipeline system, 4) help RNG interconnectors provide RNG to SoCalGas, and 5) help SoCalGas meet company goals in accepting more RNG in its pipeline system. The project team will develop a computational fluid dynamics model and validate it via demonstrations and equipment testing to provide results. The project team will deliver the results in a final report that includes experimental data, analysis of data, resemble data, and blending guidelines and recommendations. SoCalGas intends to procure and implement the proven method and plans to allow for blending Rule 45 RNG with pipeline gas before it enters the pipeline system.	
114	GO85	Seismic Risk Assessment and Management of Natural Gas Storage and Pipeline Structure (GFO-18-502)(Group 1) - two projects Slate/Berkeley & UCLA	20200109213857	Gas Operations	System Design & Materials		System Design	6/1/2019	5/31/2024	$13,000	$5,207,752	120500	$9,450		Active		SCG $13,000 | CEC $4,940,158 | LBNL $254,594	Reliability, Safety, and Improved Affordability	Late Stage (TRL 7-9)	•Field Demonstration/Validation Testing •Deployment of Results •Share/Publish Results	The CEC awarded two projects under GFO-18-502 Group 1. The projects each develop seismic risk assessment software tools using different risk models. SoCalGas is involved in both projects. The first project was awarded to Slate Geotech and UC Berkeley for the production of an open-source analysis tool that is easily usable by regulators and utilities. The tool will implement updated methodologies for assessment of seismic risk to underground and aboveground natural gas infrastructure. The tool will have the ability to identify areas of highest risk overlaid with population information to help regulators and utilities identify areas of highest risk to prioritize seismic retrofit projects. To date, a Beta version of the tool has been developed and is being tested. SoCalGas provided data and technical expertise for this project. The second project was awarded to UCLA. This project considers four hazards: Earthquake ground shaking, fault displacement, landslides and liquefaction and to develop a comprehensive set of fragility curves for pipelines and develop an open-source risk assessment tool based on probability-based methodology. To date the project is about 75% complete, and several fragility models have been developed. SoCalGas is participating on the TAP for this project. .	
115	GO86	Study on changing Accuracy & Variability of Therm zones affecting metering of new gas supplies (M2022-002)	20220422202256	Gas Operations	System Design & Materials		Materials and Equipment	4/22/2022	6/30/2023	$32,640	$367,250	$32,640	$0		Completed		SCG $32,640 | NYSEARCH Members $334,610	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	•Deployment of Results	Blending hydrogen in natural gas and renewable natural gas (RNG) will change gas properties, such as density, viscosity, and energy content. These altered gas properties may affect the flow measurement performance of natural gas flow meters and interfere with meeting the California Public Utilities Commission (CPUC) requirement of ±2% accuracy in gas delivery to customers. The objective of this project is to characterize the impact of varying hydrogen blends with natural gas and RNG on different types of residential and commercial natural gas meters. First, the project will experimentally gather gas property data that is required to calculate a mass flow rate output from a gas flow meter, compare the results with existing equations of state (EOS), and provide recommendations for best practices and setting appropriate values of uncertainties with various EOS. Secondly, the project will evaluate the suitability and integrity of common metering devices by determining measurement errors and trends when hydrogen content varies with natural gas and RNG. The result of these two tasks will be communicated via a final report and will inform gas utilities on how to determine an accurate and repeatable way to measure and bill the energy delivered to their customers with varying gas supplies. .	Hydrogen-Blending Project The project was completed prior to Resolution.
116	GO87	Study on the Impact of Trace Constituents in RNG on Natural Gas Grids and Consumer Appliances (M2020-008)	2020101905536	Gas Operations	System Design & Materials		Gas Composition And Quality - Trace Constituents	1/15/2021	12/31/2024	$71,390	$606,810	$71,390	$0		Active		SCG $71,390.00 | NYSEARCH Members $535,420.00	Environmental: Reduced GHG Emissions and Environmental: Improved Air Quality	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Modification to Regulatory Standards & Policy; Share/Publish Results	The project objective is to study the impact of trace constituents (TCs) in renewable natural gas (RNG) and traditional pipeline gas to address any potential safety or maintenance risks on local distribution company infrastructure and consumer gas appliances. The project will include a literature search and study of all TCs in RNG to identify any gaps and will perform preliminary laboratory testing on those gaps to identify set limits for six TCs of concern. These limits will assist SoCalGas in determining whether RNG specifications need modification. The team will deliver the results in a whitepaper. In 2021, the team modified the scope to include an impact study on critical TC concentrations. The team has completed the literature review, gap analysis, impact study, and testing has started. The testing includes: 1) volume swell testing, 2) visual inspection and dimensions, 3) mass change, 4) Shore D Hardness, and 5) tensile testing. Testing of consumer gas appliances has been delayed due to procurement issues. Presently, the search for a US supplier is still in progress. If the project successfully determines safe TC limits, SoCalGas plans to use the results to request changes in its Rule No. 45, the Standard Renewable Gas Interconnection, which governs business specifications and RNG tariffs.	
117	GO88	Universal Analytical Technique for Siloxane - Phase 2 (7.16.g.2)	20191007194636	Gas Operations	System Design & Materials		Gas Composition And Quality	5/1/2019	12/31/2024	$49,608	$253,000	$49,608	$0		Active		SCG $49,608 | OTD Members $203,392	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	•Modification Regulatory; Standard & Policy •Share/Publish Results	The objective of this project is to develop a universal, industry-wide sampling and analysis procedure for measuring the presence of siloxanes in biomethane. The project team is developing this procedure in collaboration with the American Society for Testing and Materials (ASTM) Committee on Gaseous Fuels. In Phase 1, the team developed and published the ASTM Standard D8230 for the Measurement of Volatile Silicon-Containing Compounds in a Gaseous Fuel Sample Using Gas Chromatography with Spectroscopic Detection. ASTM requires that an Interlaboratory Study Program (ILS) be performed within five years of the procedure publication date. In Phase 2, the team will complete the ILS and field-test an online siloxane analyzer. In 2021, the scope of work was expanded to include a second field site for Pipeline Research Council International's research project, MEAS-15-04. The team will collect periodic grab samples during the testing period for analysis at laboratories following ASTM D8230 procedures to compare the on-line data to data produced using off-line analytical techniques. In 2021, the team continued the ASTM D8230 inter-laboratory study by: finalizing details on the laboratory participation list for the ILS and continuing to plan field evaluations. .	
118	GO89	Updating Lost and Unaccounted-For (LUAF) Estimates in the Distribution System (5.23.t)	2023082223936	Gas Operations	System Design & Materials		Materials and Equipment	12/1/2023	8/31/2025	$55,884	$230,000	$0	$55,884		Active		SCG $55,884.00 | OTD Members $174,116.00	Safety, Improved Affordability	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	he objective of this project is to update the factors that contribute to the lost and unaccounted-for (LUAF) gas volume in a natural gas distribution system and apply the factors to a case study with participating utilities based on estimates of fugitive and vented emissions, meter readings and characteristics, and other contributing factors. The original study on determining LUAF gas volumes was performed by the Pacific Gas & Electric Company and SoCalGas in the early 1990's (GRI reports 90/0067 and 93/0115). Estimating the contribution of gas leaks supports emissions reporting and more efficiently directs resources to address causes. More accurate estimates of LUAF gas result in better inventory planning, which saves the supply costs. The project outcome will provide a clearer understanding of the current causes of annual gas volume variabilities and help reduce LUAF gas volumes. The project team will provide a final report that includes: 1) the description of the case study process, data collected, and general findings; and 2) quantification of the effects of different sources (i.e., measurement, leakage, accounting, and theft) of LUAF gas and identification of areas of concern or improvement. If the final report precisely identifies the current contribution of the accounting and theft components of LUAF and identifies ways to reduce their contributions to LUAF in the future, then SoCalGas would implement the identified areas of improvement to reduce the area's contribution to LUAF.	
119	GO90	Advanced Through-Tubing Casing Inspection for UGS Wells (US-4-04)	20210916213947	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	9/30/2021	3/14/2025	$272,473	$1,760,777	$72,473	$200,000		Active		SCG $272,473 | PRCI Members $630,535 | PHMSA $788,594 | Others $69,175	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	•Field Demonstration/Validation Testing •Share/Publish Results	The objective is to advance the sensor technology in through-tubing inspection tools' ability to detect, measure, and characterize metal loss features. This project is looking to work with PRCI to offer a Multi-String Well Integrity Platform that provides a circumferential measurement of corrosion and isolation of external casing strings. The proposed solution will be a fully combinable, advanced sensor technology. The combo will be capable of acquiring data in a single run without pulling out the production tubing. The development of this technological advancement will significantly save UGS operators time and cost by providing the means to evaluate well integrity and effectively plan well intervention activities. SoCalGas would utilize the results to manage well integrity as outlined in each fields Storage Risk Management Plan. The project kick-off meeting was held in November 2021 highlighting the general project objectives, work scope, schedule and responsibilities. The overall project execution plan and regular project meeting schedule were also discussed. SoCalGas would utilize the results to manage well integrity as outlined in each fields Storage Risk Management Plan. .	
120	GO91	Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends (7.23.f)	202211232159	Gas Operations	System Inspection & Monitoring		Pipeline Monitoring Systems (Sensors)	12/1/2022	12/31/2025	$87,896	$1,562,946	$87,896	$0		Active		SCG $87,896.00 | OTD Members $350,604.00 | PHMSA $749,446.00 | Other $375,000.00	Safety	Mid Stage (TRL 4-6)	Share/Publish Results	This project aims to understand and advance leak-sensing technologies to detect hydrogen (H_2) and natural gas (NG) blends as utilities move towards cleaner gas. Ensuring that leaks are detected quickly and efficiently, mitigating the potential harm caused by undetected leaks, and minimizing misinterpreted leak detection results can reinforce safety as the need for new leak detection sensing schemes for H_2 and H_2/NG blends increases. The project team, consisting of GTI Energy and SENSIT Technologies, will perform the following tasks: 1) evaluate leak detection equipment currently used by NG pipeline operators; 2) guide new and altered usage protocols; 3) validate the H_2 blending threshold at which these devices become ineffective; 4) quantitatively map out the impact of varying amounts of H_2 on the calibration and analytics of currently used leak detection equipment, and 5) develop a proof-of-concept H_2 detection scheme to remedy technology gaps. Upon completion, the project team will deliver new leak detection sensing schemes, ten detailed statistical analyses of laboratory and field testing, an OTD and PHMSA confidential report, a public paper, and a conference presentation. The results from the literature review, leak detection methodology, and sensing specifications could benefit SoCalGas in refining company leak detection policies.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Project results will support the hydrogen blending pilot projects. SoCalGas will hosting a field demonstration to help validate potential technologies. 2) Testing and influencing developing leak technologies that support the planning and execution of the hydrogen blending demonstration projects. This could influence PHMSA (federal codes/regulations) when evaluating technologies for monitoring and surveying systems with hydrogen and blends. SoCalGas has requested the use of clean renewable hydrogen to be included this projects scope. The project completed some testing prior to the resolution.

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121	GO92	Aerial Methane Monitoring of High-Pressure Distribution System	2023011723722	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	12/14/2022	1/31/2024	$16,369	$16,369	$16,369	$0	$16,369	Active		SCG $16369.00 | None $0.00	Safety and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Technology & Knowledge Transfer/Training	This project aims to conduct and perform a comparative analysis between SoCalGas' current mobile leak survey practice and an aerial-based survey (AMM GML) for high-pressure distribution supply lines. Additionally, it will evaluate the potential operational cost savings associated with utilizing an aerial-based survey for these infrastructure segments. Natural gas transmission lines are tightly regulated, and monitoring transmission pipelines more efficiently and effectively to reduce emissions is crucial for meeting regulatory requirements and SoCalGas safety and environmental goals. The team will simultaneously conduct mobile and aerial-based surveys along 10 miles of a high-pressure distribution main in increments of 1-mile segments. Using an aerial-based survey for high-pressure distribution lines can significantly reduce the time required to survey these assets while also reducing the cost of purchasing, maintaining, and operating mobile-based equipment on fleet vehicles and the number of personnel needed to handle them. Aerial-based surveys could eliminate slower manual tasks and minimize or prevent hazardous, adverse conditions around resources. SoCalGas will utilize the study's results to evaluate potential operational cost savings associated with switching to an aerial-based survey for high-pressure distribution supply line infrastructure segments.	
122	GO93	Airborne Automated Threat Detection System-Monitoring and Surveillance of Imminent Threats Through Remote Sensing (ROW-3-1&A)	2018112659	Gas Operations	System Inspection & Monitoring		GeoHazard Threat Inspection and Monitoring	11/30/2018	12/11/2023	$10,982	$377,683	$10,982	$0		Completed		SCG $10,982.00 | PRCI Members $366,701.00	Reliability and Safety	Late Stage (TRL 7-9)	Further Technology Development/Prototype; Field Demonstration/Validation Testing; Commercialization; Technology & Knowledge Transfer/Training;	The project's goals are to develop, demonstrate, and validate automated pipeline patrol and surveillance technologies on an aircraft platform to enhance the detection of third-party activities, ground movement, and other interference that poses risks to pipeline infrastructure. The project team generated data from multiple sensors deployed on aerial patrolto assess the capabilities and limitations of the airborne sensing systems for automated pipeline patrol. The project team made significant progress in validating the performance of an automated Right-Of-Way (ROW) monitoring and surveillance system, operating on long-range, long-endurance, and Beyond Visual Line of Sight (BVLOS) unmanned aircraft. The team gathered data through remote sensing in near-real time. In 2022, a Computing Environment System was developed to support flood detection at river crossings and other threat sources (fires, logging, etc.). Additionally, it supports a proof of concept for detecting liquid hydrocarbon leaks using changes in vegetative health. The final report for the PHMSA co-funded portion of the project was published. The final flight campaign is scheduled for Q4 of 2022. It will be conducted over a pipeline corridor testing the InstiMaps Gen-4 system in a conventional aircraft and BVLOS in an unmanned aerial aircraft. Once the final flight is completed and the results analyzed, the PRCI Final Report will be prepared and submitted to sponsors for review and approval. The results of this project will provide pipeline operators with performance data and information on the capabilities and limitations of airborne sensing systems for automated pipeline patrol to improve surveillance of pipeline ROW corridors.	
123	GO94	Alternate Crack Sensor (M2016-004 Ph IV)	164411262	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	8/9/2021	11/28/2023	$70,190	$491,324	$70,190	$0		Completed		SCG $70,190 | NYSEARCH Members $421,134	Reliability and Safety	Mid Stage (TRL 4-6)	•Field Demonstration/Validation Testing •Commercialization	The project team developed and commercialized a sensor probe system for crack detection in longitudinal seam welds (SWs) in 20"-26" diameter natural gas pipelines. In Phase 1, the team developed a concept to integrate the crack sensor probe with the Explorer robotic inspection platform. The concept used two probes: one for finding SWs and one for scanning for cracks. In Phase 2, a prototype was built and field-tested. The sensor successfully identified cracks in all SWs except for electric resistance welds (ERWs). In Phase 3, mechanical designs were refined to improve weld sensor ride and data quality, especially over protruding SWs. Further, the ERW SW detection was improved, such that the data proved consistent and accurate when detecting girth SWs, allowing a smooth operation of orientation transitions between pipeline segments. Data Analysis Tools were improved through testing and fine-tuning the integration of the weld sensor data to the analysis software. At the completion of Phase 3, sponsors elected to continue onto a Phase 4 where the focus is to improve the existing system (developed in Phase 1-3 of this program) with revisions to the mechanical design, weld detection capability and integrations with the Explorer 20/26 robot and operation. The deliverables are to be a revised circumferential MFL sensing system able to detect long SW anomalies as documented in the early phases, an alternative sensor probe for improving detection of low signature long SW, and established specifications of operation. Phase 4 kicked off in August 2021 and began testing to increase the sensitivity of the weld and material detection and modifications to the sensor housing to reduce the weight were made. .	
124	GO95	Database of All Burst Tests for Corrosion, Cracking, Dent, and Interacting Defects (EC-2-11)	20211208175940	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/19/2021	9/13/2023	$8,780	$147,500	$8,780	$0		Completed		SCG $8,780 | PRCI Members $138,720	Safety	Mid Stage (TRL 4-6)	•Modification to Regulator; Policy & Standards •Share/Publish Results	The objective of this project is to develop and populate a database of burst tests for corrosion, cracking, dent, and interacting defects including fatigue tests. To validate improvement in defect assessment or modelling, burst tests and fatigue tests are usually done. These tests are time consuming and expensive, and finding the appropriate pipe samples for testing is also challenging. The project would develop a uniform format for burst test data collection and support future defect assessment and modeling efforts. The benefit of this project is to provide consistent and relevant data for future Pipeline Research Council International (PRCI) studies in defect assessment and growth modelling. The outcome is a database of burst tests and fatigue tests with open access to members. .	
125	GO96	Develop guideline for API 1163 for Inspections Qualification for Level 1, 2, and 3 (IM-1-06)	20220427214251	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	3/25/2022	3/25/2023	$6,313	$154,000	$6,313	$0		Completed		SCG $6,313 | PRCI Members $147,687	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	•Deployment of Results •Share/Publish Results	API Standard 1163 provides requirements for qualification of in-line inspection (ILI) systems. The standard covers the selection, reporting, verification, and three levels of validation associated with in-line inspection systems. The standard also outlines the complexity and cost increase with each level of validation. This project will develop guidelines and procedures for utilities to implement the three levels of validation as prescribed in API 1163 in the qualification and validation of tools for inspection. The emphasis of the project is on developing guidelines and statistical methods to be used for level 1, 2 and 3 analyses. The project will also develop software for level 2 and 3 analyses. The results of this project will help utilities in determining and selecting the validation level that will optimize integrity management resources and reduce overall risk. Ratepayers will benefit from safer and more cost-effective pipeline operations. SoCalGas sponsors this project so that Integrity Management can improve its guidelines describing when level 1, 2 and 3 validation levels are applicable. Integrity Management is particularly interested in defining when a Level 1 validation can be used on pipelines, especially when insufficient anomalies are available for excavation to conduct a level 2 validation. In lieu of excavating anomalies to perform a level 2 validation, a Level 1 validation uses statistical analysis to validate the performance of the ILI tool. .	
126	GO97	Downhole Inspection Tool Performance Evaluation	202301041945	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	1/8/2022	5/31/2024	$2,092,939	$2,092,939	$1,907,939	$185,000	$1,495,432	Active		SCG $2,092,938.66 | None $0.00	Reliability and Safety	Late Stage (TRL 7-9)	New Research Project to Advance TRL; Field Demonstration/Validation Testing	The objective of this project is to enhance SoCalGas's (SCG) understanding of new downhole inspection tools used to assess the integrity of gas storage well casing and tubing. Inspection tools will be tested by running them inside fabricated tubing and casing pipe with manufactured anomalies. The measured inspection results will be compared with the known anomaly dimensions to evaluate inspection tool performance and accuracy, i.e., "pull testing." A greater understanding of downhole inspection tool performance will enhance future integrity assessments of gas storage well casing and tubing. In 2022, proof of concept work was completed for a novel high-resolution ultrasonic thickness (UT) inspection tool. The tool was run in four gas storage wells, and its results compared well to established UT and magnetic flux leakage tools. The high-resolution UT tool has been added to the list of tools to be pull-tested. In preparation for upcoming pull testing, tubing and casing were fabricated with manufactured anomalies of known dimensions. In 2023, SCG plans to conduct the pull testing and analyze the results. Through this research, SCG will gain a better understanding of new inspection tool performance and limitations.	
127	GO98	Eclipse Scientific Red/Green Light Tool for NDE of PE Pipe Butt Fusion Joints - Phase 1-a (M2019-010)	20200102235619	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	1/31/2020	3/31/2023	$13,670	$153,790	$12,000	$1,670		Completed		SCG $13,670.00 | NYSEARCH Members $140,120.00	Reliability, Safety, and Improved Affordability	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	Pipefusers can join polyethylene (PE) pipes by melting both ends and forcing the ends together to form a butt-fusion (BF) joint. The integrity of the BF joint is important for long-term performance. This project will develop an automated non-destructive examination (NDE) tool to inspect the integrity of BF joints which does not require operators with specialized training in NDE. NYSEARCH members have invested considerable resources into NDE development for PE pipe through extensive testing with The Welding Institute. Eclipse Scientific has developed the automated NDE constructs of pass/fail (green/red) for performing PE joint pipe interrogation. This project received a portion of the defected BF joint samples developed under the M2019-009 project and completed all the scans of PE pipe standard and defect pipe to continue the integration of automated defect recognition within NDE pass/fail (green/red) characterization. In 2022, additional samples were shipped to the project team to continue the scan of defective samples building the dataset. Artificial Intelligence will use the library of scanned standard and defect pipe samples and the acceptance criteria to base NDE decisions. These scans provide the basis for automated anomaly identification and interrogation of deciding on a pass/fail during an NDE PE pipe inspection. The project team will provide the final report summarizing the tool's performance at the end of the project. The development of this technology will improve the integrity of BF joints constructed by SoCalGas since any defect in the joint would be identified before placing the pipe into service.	
128	GO99	Electromagnetic Time Domain Reflectometry (EM-TDR) for Pipeline Integrity (M2021-004 Ph I)	2021052765423	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	5/1/2021	3/29/2024	$28,850	$339,000	$28,850	$0		Active		SCG $28,850 | NYSEARCH Members $310,150	Reliability and Safety	Early Stage (TRL 1-3)	•New Research Project to Advance TRL Level •Further Technology Development/Prototype	Electromagnetic Time Domain Reflectometry (EM-TDR) is a mature technique developed to identify and locate faults in metallic cables. Lawrence Berkeley National Lab (LBNL) proposes to adopt the EM-TDR technique to the inspection of transmission natural gas pipelines. Variations in materials and pipeline geometry have a significant effect on this technique's performance and tuning. This project will evaluate method feasibility for the intended application, and if successful, it will lead to additional phases to develop and test an engineering prototype, a pre-commercial protype and ultimately result in commercialization. This technology would allow for SoCalGas to obtain more information on difficult- to -access portions of pipelines that are currently assessed by External Corrosion Direct Assessment (ECDA). If this tool is applicable to pipelines as outlined in the proposal, EM-TDR could be used to provide further assessment of carrier pipe within cased segments, as well as other crossings where ECDA techniques are not available. This tool would be used to supplement and enhance existing ECDA inspection techniques. .	
129	GO100	Energy Harvesting in Gas Industry Applications (M2016-006) - Phase I/II	20191003213535	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	12/1/2016	5/19/2023	$27,931	$293,235	$18,931	$9,000		Completed		SCG $27,931.00 | NYSEARCH Members $265,304.00	Reliability, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing	The project aims to conduct a feasibility study to identify technologies that generate 3-5 watts of power by harvesting energy from available "background" resources (e.g., vibration, flow, temperature differences, etc.). This effort will provide power to sensory and related devices in areas where utility power is limited or non-existent and remove the need for replacing batteries. In Phase I, the team initiated a feasibility study to determine if energy harvesting using the energy available in the system's environment could be converted to power and identified four potential technologies: (1) vibration energy, (2) fuel cell energy, (3) thermal energy, and (4) fluid flow energy. In phase II, the team will evaluate the technologies for practicality and commercial availability. In 2022, the project team looked at two energy harvesters, the thermoelectric generator and the electrodynamic turbine generator. Field testing was performed in Q4 2022 using a 20-watt thermoelectric generator to convert heat energy from gas burning into electricity and for the electrodynamic turbine generator. Analysis of the test results is in progress, with the Final Report scheduled for release to sponsors in Q1 2023. Once the team completes the project, SoCalGas will analyze and review the results to determine if they should further study the equipment for operations.	
130	GO101	Explorer Automation Demonstration	20230817185327	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	12/1/2023	12/31/2025	$800,000	$800,000	$0	$800,000		Active		SCG $800,000.00	Reliability,Operational Efficiency, and Improved Affordability	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this research is to support Integrity Management to field test a pipe explorer in-line inspection (ILI) tool. This ILI tool is an improvement to traditional inspection robotic platforms. The tool is a wireless-self-propelled inspection tool used for traditional and unpiggable steel pipe inspection. The automatic explorer features wireless in-line charging, new metal loss and deformation sensors, axially orientated to target crack-like features on or near long seam weld and can maneuver through back-to-back elbows at 45°/90° mitered bends. The ILI tool will be demonstrated at one of SoCalGas' 30-inch transmission line. In 2023, the project team discussed and submitted feedback to the Master Service Agreement between SoCalGas and the vendor. The demonstration is scheduled to begin in early 2025. SoCalGas can use this research to add to the list of tools to identify features for integrity management which will benefit ratepayers by augmenting operational efficiency, reliability, and improved affordability.	

1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
131	GO102	Explorer Wireless Range Extender (M2021-006 Ph II)	2022042218954	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	4/22/2022	5/31/2024	$83,240	$736,788	$59,675	$0	$23,565	Active		SCG $59,675.00 | NYSEARCH Members $482,725.00	Reliability, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Commercialization; Share/Publish Results	This project builds on Phase I, in which the project team performed a feasibility study for extending the wireless communication range of the existing Explorer In-Line inspection robot while deployed in the gas pipeline. The project team will implement the recommendations from Phase I and develop a prototype that can be demonstrated in the gas infrastructure. This project consists of six tasks: 1) Concept Review and Detailed Design, 2) Manufacturing and Assembly, 3) Full System Testing, 4) Investigation of Implementation in Other Robot Sizes, 5) Communication Protocol Enhancements, and 6) the Final Report. In 2022, a feasibility study was completed and reported that a significant communication range extension is possible with combinations of wireless technologies and in-pipe antenna deployment via range extender modules (REM). The update to the mechanical design to fit within a 15-inch diameter, meet weight requirements, and provide a more robust and efficient system, is 80% complete. The electrical design is finished. The next steps will finalize the coding and design of the firmware, graphical user interface, mechanical drawings, procurement of mechanical parts, assembly, and testing. The project deliverable will be a report and a prototype that can be commercialized. SoCalGas will benefit from this project by using the commercialized prototype to increase the efficiency of its pipeline inspection and reduce the overall inspection cost.	
132	GO103	Extending Energy Harvesting to Other Explorer Sizes - A Feasibility Study (M2021-011)	2021110821722	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/15/2021	5/31/2026	$19,395	$193,948	$19,395	$0		Active		SCG $19,395.00 | NYSEARCH Members $174,553.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing; Commercialization; Share/Publish Results	The objective of this project is to perform a feasibility study on the scalability of the Explorer 20/26 Energy Harvesting (EH) system, equipped to function within 20” and 26” diameter pipe, to other platforms and specifically to determine the performance envelope for the Explorer 10/14, 16/18, and 30/36, within 10” and 14”, 16” and 18”, and 30” and 36” diameter pipe, respectively. This project consists of five tasks: 1) the team will perform an analysis on the robot to determine its power consumption under various operational conditions and the energy and tow force that can be generated for the robot within different pipe sizes; 2) the team will investigate the mechanical design of the EH system and its impact on the overall weight of the robot; 3) & 4) the team will evaluate the amount of power and energy generated for different pipe sizes under different operating conditions, and they will modify the EH system’s electronics, if necessary; and 5) will explore the potential impacts of the EH technology in its commercial deployment across various Explorer robot platforms. The team will deliver a report outlining the tasks conducted during the feasibility study, including 1) the key parameters for an EH system for different pipe sizes of the Explorer fleet; 2) remedying technical obstacles that EH systems need to overcome to be successfully developed in future phases, and 3) recommendations on the next steps. The project kicked off in May 2022 but is currently on hold until 2023 due to resource constraints. This project, if successful, will expand the inspection capabilities of the Explorer robotic tools and allow the SoCalGas in-line inspection (ILI) program to collect more data and conduct longer inspections.	
133	GO104	Ground Cover Change Detection for Transmission Pipelines (8.23.k)	2020022743825	Gas Operations	System Inspection & Monitoring		GeoHazard Threat Inspection and Monitoring	12/1/2023	3/31/2025	$53,100	$190,000	$0	$53,100		Active		SCG $48,100.00 | OTD Members $136,900.00	Reliability, Safety, Operational Efficiency	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Deployment of Results	The objectives of this project are to evaluate existing manual, time-consuming, and costly processes for monitoring pipelines and to automate the processes for identifying threats around transmission pipelines. The project will identify cost-effective modern technologies and methodologies that may enhance the monitoring of critical assets and help identify previously undetected threats. The project team held a kick-off meeting and determined the project would address weather-related outside forces in ground cover detection for potential landslide, erosion, and change detection of pipeline crossing agriculture land. The project team conducted the project scoping and developed the research methodology to focus on short-range (instrument attached to a vehicle) and remote (satellite) detection technologies. The next step is to perform market research of commercially available technologies for ground coverage change detection, object detection, and other similar use cases that might have applications for transmission pipeline monitoring. The project deliverables include: 1) project scoping, 2) market research, 3) lab testing, 4) a field demonstration within SoCalGas territory, and 5) a final report. Identifying processes that simplify and improve these monitoring activities will improve the safety, reliability, and cost-effectiveness of our operations. SoCalGas will use this research to improve processes that could aid in identifying threat areas caused by potential mechanical damage and weather-related outside forces.	
134	GO105	Hard Spot Detection (MAT-7-2A)	20230908215351	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	12/1/2023	5/31/2025	$15,000	$900,000	$0	$15,000		Active		SCG $15,000 | PRCI Members $885,000	Reliability and Safety	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results	The objective of this project is to assess various inline inspection (ILI) tools to help operators streamline hard-to-detect hard spots. Hard spots are areas on the pipe with hardness levels higher than the surrounding pipe. Hard spots are locations that can be more susceptible to cracking mechanisms such as bending strain and corrosion. In pipelines with blended gas, any internal abnormality initiated at a hard spot could likely grow as hydrogen is a smaller molecule compared to methane. This occurrence has the potential for hydrogen seepage, which is known to affect material integrity. ILI tools that can identify hard spots, as well as recognize metallurgical properties, grade determination, and fracture behavior are important elements to any integrity program. SoCalGas anticipates using the results of this project for guidance on identifying pipeline segments with susceptibility to hard spots, assessing the effectiveness of commercially available hard spot detection tools, evaluating the potential impact of cathodic protection on hard spots, and providing information that could improve the management and response criteria.	
135	GO106	High Resolution MFL for Explorer Series of Robotic Platforms - Feasibility Study (M2021-009)	20211108181931	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/15/2021	8/1/2024	$23,900	$215,084	$23,900	$0		Active		SCG $23,900.00 | NYSEARCH Members $191,184.00	Safety and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; Further Technology Development/Prototype; Share/Publish Results	The objective of this project is to do a feasibility study on integrating a high-resolution magnetic flux leakage (MFL) sensor onto the Explorer robot platform, assess multiple commercially available sensors, and optimize the resulting system for maximum efficiency and interchangeability among the various robots. This project has four tasks: 1) determine the best sensor for the application while considering potential solutions to implementation issues (i.e., sensor control, data transfer); 2) identify various concepts for sensor positioning and design schemes, and select the best one; 3) build a benchtop prototype system based on the design selected in Task 2 to validate optimal integration into the magnetic bars and performance (data collection and transfer, sensor resolution, defect sizing resolution, etc.); and 4) summarize the results with a recommendation for implementing the new sensors on the MFL module. The project was kicked off in early 2022, but due to resource constraints, the tasks will begin in early 2023. The next step will be to complete a feasibility study and then build and test the proof-of-concept prototype. The team will deliver a benchtop prototype system along with a feasibility analysis report and recommendations on the next steps. Improving the sensor capabilities of the Explorer family of robotic platforms will be of benefit to the SoCalGas In-line Inspection program because the smaller sensors will allow for higher spatial and circumferential resolution and detectability of smaller defects with higher resolution, therefore, allowing higher confidence levels in the measurements made.	
136	GO107	ILI-Based Generic External Corrosion Growth Rate Distribution for Buried Pipelines (EC-01-13)	202105071759	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	6/23/2021	12/15/2023	$19,308	$193,662	$19,308	$0		Completed		SCG $19,308.00 | PRCI Members $174,354.00	Reliability and Safety	Mid Stage (TRL 4-6)	New Research Project to Advance TRL,	The goal of this project is to provide the industry with generalized in-line inspection (ILI) based corrosion growth rate distributions and associated causal factors. The distributions will be based on actual data from successive ILI runs provided by Pipeline Research Council International members. The project will develop a probabilistic model for estimating external corrosion growth (ECG) rates via successive ILI runs. The team will analyze in-the-ditch inspection data to determine statistical corrosion depth distributions. They will also perform a literature review for various ECG rate estimation strategies, which will help them decide if any existing models can be utilized. In 2022, the project team collected ILI data from sponsors to refine the Bayesian Network variables. The project team continues to implement key parameters in updating the Multi-Analytic Risk Management (MARVTM) tool, a Bayesian Network approach for statistically quantifying risk and corrosion growth. The software is already developed, but the team will refine it during this project based on recent industry work and input from industry subject matter experts. Local distribution companies will continue to develop and refine the ECG rate probability curves. A better understanding of ECG rates along the pipeline could result in more accurate reassessment intervals, allowing member companies to optimize ILIs for metal loss. SoCalGas will utilize the research study’s applicability in increasing the accuracy of ECG rate calculations to determine the remaining life of the pipeline. After evaluation, SoCalGas could benefit from this research by potentially integrating the deliverables into the company-specific Transmission Integrity Management Program.	
137	GO108	Improve ILI Sizing Accuracy (PHMSA) (NDE-4-19)	20200203203815	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	9/30/2019	6/30/2023	$5,000	$2,251,100	$5,000	$0		Completed		SCG $5,000.00 | PRCI Members $605,923.00 | PHMSA $725,000.00 | Technology Providers $725,000.00	Reliability and Safety	Mid Stage (TRL 4-6)	Further Technology Development/Prototype; Technology & Knowledge Transfer/Training;	The goal of this project is to understand the probability of detection by state-of-the-art In-Line Inspection (ILI) tools for internal anomalies in steel pipes. It is important to understand the likelihood of identifying abnormalities in the steel pipe as it 1) can minimize the number of missed defects without increasing the number of false indications, 2) optimize the number of excavations needed for operation pipeline safety, and 3) allow for more efficient utilization of resources. Research outcomes will improve ILI sizing accuracy of cracking, crack-like anomalies, and corrosion anomalies and allow ILI technology developers to improve and adjust sizing algorithms for these anomalies. In addition, developers can re-run tools on test strings with modified sensors, sensor configurations, and sizing algorithms. In December 2021, the ILI Technology Providers completed the delivery of the ILI reports for the initial (blind) test. In 2022, they were asked to detect and characterize a blind set of metal loss anomalies and evaluate detection, identification, and sizing capabilities for each defect type. The ILI performance evaluation and data verifications are in progress, and providers are currently comparing truth data to ILI results. PHMSA has granted a time extension for the project due to extended vendor timeframes for data processing and improvement analysis, and reporting with potential retesting. SoCalGas can use this research to improve ILI vendors’ sizing accuracy, which will benefit in targeted excavations toward potentially immediate conditions.	
138	GO109	INGAA - Geohazard Management JIP	20220719234857	Gas Operations	System Inspection & Monitoring		GeoHazard Threat Inspection and Monitoring	7/18/2022	9/26/2023	$37,996	$562,996	$37,996	$0		Completed		SCG $37,996.00 | JIP Members $525,000.00	Reliability and Safety	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Share/Publish Results	The objective of this project is to provide a high-level, concise framework for pipeline operators to utilize in managing geohazards considering no best practices or recommended procedures for geohazard data management currently exist. This set of documents will include a detailed recommended practice (RP) and a guide for implementing and executing a geohazard land movement management program. A secondary goal is to support potential rulemaking by the Pipeline and Hazardous Materials Safety Administration (PHMSA) related to geohazard management. The project team will produce a published RP by the American Petroleum Institute (API). The team has reviewed various PHSMA and European data sets addressing gas and liquid incidents caused by Weather-Related Outside Forces and interviewed sponsors about their geohazard integrity management programs. Additionally, the project team is working on a high-level framework paper for geohazard management with an expected completion date in January 2023. A second paper will provide an RP for landslide integrity management, with expected completion in March 2023, and will likely be added to API RP 1187. The team reviewed both draft papers with comments in November 2022. Upon completion, the aforementioned documents could aid SoCalGas with its geohazard management framework and landslide threat evaluations.	
139	GO110	Innovative Leak Detection Methods for	202211113941	Gas Operations	System Inspection & Monitoring		Data Analytics	9/29/2022	9/28/2025	$13,393	$547,226	$13,393	$0		Active		SCG $13,393.00 | PRCI Members, PHMSA $533,833.00	Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Deployment of Results	The objective of this project is to develop 1) improved algorithms to estimate pipeline inventories lacking full pipeline transient modeling applications, 2) a new algorithm for enhanced zone balancing calculations, 3) pattern identification methods that identify how corrected zone balances shift due to changes in system flow, which the project team will use to identify meters that are most likely attributing to measurement flow errors, and 4) recommended practices to troubleshoot facilities with high error probabilities. Computational pipeline monitoring (CPM) systems have technology gaps. For example, 1) balancing zones are minimal in number and encompass too large areas, 2) retrofitted inline flow measurement systems are difficult to install, 3) challenges faced with changes in gas pipeline systems inventory or distinguishing measurement errors from leaks, and 4) unavailable, infrequent, or asynchronous data. Addressing these gaps will enhance CPM leak detection methods by detecting and locating leaks more accurately and quickly. The project team will test the developed algorithms and methods on simulated systems and then validate them on a gas pipeline system. This research could reduce 1) lost, and unaccounted-for volumes of gas, 2) impacts on safety, and 3) impacts on the environment. The results will be presented in a final report and at a public forum. The developed algorithms and methods could be used in SoCalGas measurement accounting systems if successful and compatible.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
140	GO111	Internal Corrosion Management	2023011722739	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/17/2022	11/30/2023	$88,833	$88,833	$88,833	$0	$88,833	Completed		SCG $88,833 | None $0.00	Reliability and Safety	Early Stage (TRL 1-3)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to review existing processes and data associated with "potentially corrosive constituents" as identified in 49 C.F.R. § 192.478 to evaluate whether changes should be implemented to comply with recent federal regulations. Potentially corrosive constituents include, but are not limited to: carbon dioxide, hydrogen sulfide, sulfur, microbes, and liquid water. In task 1, the project team will review SoCalGas procedures. In task 2, the project team will create a flow diagram for the data currently being collected. The project deliverables will include a report identifying next steps, such as preparing a white paper documenting the known limits for constituents or additional research which needs to be performed.	
141	GO112	Low Flow EMAT ILI Tool Demonstration (qi II)	20220214204743	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/26/2021	9/30/2024	$225,000	$225,000	$0	$225,000		Active		SCG $225,000.00 | None $0.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Deployment of Results; Technology & Knowledge Transfer/Training	The goal of this project is to demonstrate the capabilities of the 12" and 16" free-swimming Electromagnetic Acoustic Transducer (EMAT) tool with a field demonstration inspecting SoCalGas transmission pipelines. Many In-line-Inspection (ILI) technologies use a Magnetic Flux Leakage (MFL) detection method to measure wall loss on metallic pipelines due to internal and external corrosion. Under previous research projects, an EMAT sensor and robotic platform for small-diameter unpiggable pipelines capable of identifying smaller defects than traditional MFL tools were developed for commercialization. Building upon this research, a free-swimming version of the tool has been created. Free-swimming tools are of interest to subject matter experts such that the tools are propelled by the flow of internal pipeline pressures. The demonstration was moved to 2023 to allow Integrity Management to complete a feasibility review of the pipelines. If the demonstration is successful, SoCalGas will have an alternative for performing pipeline inspections on unpiggable pipelines with traditional tools.	
142	GO113	Microbial Influence Corrosion (MIC) Detection (GFO-21-506, Group 2)	20221216173640	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	10/25/2022	9/30/2026	$75,000	$1,518,920	$38,854	$36,146	$38,854	Active		SCG $75,000.00 | CEC $999,970.00| Others $443,950.00	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish Results; Technology & Knowledge Transfer/Training	The project objective is to develop and pilot a self-contained portable microbial detection kit that will allow fast detection and identification of various corrosion-related microbes from raw samples with minimal hands-on time. Microbial testing is an essential component in detecting, controlling, and mitigating microbiologically influenced corrosion (MIC) in natural gas systems. Current testing approaches are hampered by long wait times, the inability of rapid tests to identify specific corrosion-related microorganisms, and complex sample preparation and testing processes that require laboratory equipment or highly specialized personnel. The team has scheduled the project to begin in February 2023, with field pilot demonstrations performed under various environmental conditions after that. The project deliverables include Test Kit Documentation and a Field-Testing Guide, which will build the foundation for developing new approaches for detecting, monitoring, predicting, and controlling microbial corrosion in California's natural gas pipeline systems. The primary benefit will be the timely detection of specific corrosion-related microbes in pipelines and storage tanks which will provide a basis for developing targeted strategies for the control of microbial corrosion and reduce the use of expensive and environmentally toxic broad-spectrum biocides. SoCalGas intends to use the research and development of the portable microbial detection kit as it will potentially provide a more accessible and lower-cost method to detect and identify the presence of microbiologically influenced corrosion (MIC) in natural gas systems.	
143	GO114	Modernize the Assessment of Pipeline Water Crossings (ENV-4-1A)	2018112166	Gas Operations	System Inspection & Monitoring		GeoHazard Threat Inspection and Monitoring	1/1/2019	4/17/2023	$24,119	$740,035	$24,119	$0		Completed		SCG $24,119.00 | PRCI Members $329,712.00 | PHMSA $386,204.00	Safety and Improved Affordability	Late Stage (TRL 7-9)	Share/Publish Results	The objective of this project is to improve the capabilities of existing streamflow monitoring techniques and engineering and risk assessment tools used for managing the integrity of pipeline crossings over waterways. The project tasks include field verification of scour and erosion prediction from hydrology hydraulics and fluvial geomorphology; field validation of Vortex-Induced Vibration (VIV) initiation within waterways to determine pipeline limitations and VIV avoidance criteria. The goal is to allow operators to identify crossings that require operational (e.g., monitoring) or engineering (e.g., mitigation) controls to lower the probability of flooding hazards that can lead to containment loss. The project team will build and test a prototype website-based alert dashboard. The dashboard could also be a screening tool to plan new waterway crossings. The results of this project can supplement the guidance provided in API RP 1133, Managing Hydrotechnical Hazards for Pipelines Located Onshore or Within Coastal Zone Areas. To date, the project team has delivered nine of nine final reports to PRCI members. Eight are available on the Pipeline Research Council international website. The team anticipates completing the final project report in early 2023. SoCalGas will use this information as a knowledge base for evaluating and maintaining pipeline water crossings.	
144	GO115	NDE Tool for Electrofusion Fittings (M2022-004)	20210517163051	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	8/30/2022	3/31/2024	$16,925	$156,575	$16,925	$0		Active		SCG $16,925.00 | NYSEARCH Members $139,650.00	Reliability and Safety	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing	Inspecting Polyethylene (PE) Electrofusion (EF) fitting joints is an important quality control check, confirming that the fusion between the pipe and EF fitting has properly formed, ensuring its long-term performance. Currently, inspection is limited to visual observation of the final exterior joint surface due to the EF joint's internal configuration. Without direct observation of each step in preparing the PE pipe and EF fitting, there is no opportunity to assess a final EF joint internal configuration after the fusion between the PE pipe and fitting is complete. However, there are non-destructive evaluation (NDE) methods available to look beyond the outer surfaces of EF PE pipe fusions. This approach provides high granularity inspection capabilities of the joined material between the PE pipe and fitting. These NDE techniques require highly trained and experienced NDE personnel to perform the testing and interpreting of the results. A method of NDE inspection is desired to enable a non-NDE expert to look within the EF joint internally to observe the general configuration, confirming an acceptable fusion has been obtained. The scope of this project is to develop an NDE technique for visual examination of the internals of a PE pipe EF fitting using a digital x-ray. This research will include 1) an NDE digital x-ray and quality control interpretation method, 2) an application for personnel who are non-experts in NDE methods to perform field procedures, and 3) training guidelines for setting up and performing NDE in a safe, effective, and efficient manner. SoCalGas can use this X-ray system in the field to assess PE EF joint quality before installing fused piping in the ground, which would contribute to pipeline safety and integrity.	
145	GO116	NJIT Advanced Terahertz (THz) Imaging & Spectroscopy for Non-Destructive Evaluation of Polyethylene Pipes (M2018-009 PhII)	20200630224116	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	7/1/2020	3/31/2025	$59,615	$902,581	$42,700	$16,915		Active		SCG $59,615.00 | NYSEARCH Members $633,932.00	Reliability and Safety	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype	Technology advancements may be useful in assessing the quality of questionable butt fusion (BF) joints and may prevent unnecessary cutouts of good BF joints with the appearance of a bad fusion. The objective of this research project is to continue the development of terahertz (THz) time-domain spectroscopy and imaging for the nondestructive evaluation (NDE) of PE gas pipeline BF joints. Phase II evaluates the THz capability on BF joint samples with inclusions at the acceptance criteria threshold. The team has performed extensive NDE inspections of specific PE joint defects containing a lack of fusion. The birefringent application to the THz NDE process has advanced with improved inspection procedures and analytical signal processing. In 2022, the project team worked on improving signal resolution using the THz inspection process during scan interpretation to identify potential defects, including "cold" or lack of fusion within the BF. The project team will provide a final report, including the results of technical assessments of THz NDE potential for plastic pipes, at the end of the project.	
146	GO117	Pipeline Cleaning Tool for Liquids with Flow (M2017-006 Ph II)	20210507142215	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	5/6/2021	8/15/2023	$79,765	$339,000	$79,765	$0		Completed		SCG $76,530.00 | NYSEARCH Members $902,581.00	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	Further Technology Development/Prototype; Field Demonstration/Validation Testing; Commercialization	InvoDane will develop and test expanding the capability of the 20/26 Explorer robot, which is capable of inspecting "difficult-to-inspect" pipes while remaining in service, to drive and scan through an accumulated liquid in the natural gas pipelines. When inspection teams find liquids in the pipeline, inspections must stop until they remove the liquids before proceeding with the examination. With regulatory-driven due dates, delays in completing assessments can result in non-compliance. This research, if successful, will allow inspection teams to continue without the need to halt for liquid removal. Pre-commercialized liquid-capable drive tracks and magnet bars will be designed and tested for retrofit onto an Explorer 20/26 robot and included on future-generation robots. In 2022, the project team had the components manufactured, and they completed testing on the magnet bar and drive tracks. The liquid-capable testing of the modules is underway. In early 2023, the project team will perform the final tests to verify the validity of the design. After this project, InvoDane plans to build several sets of liquid-capable drive tracks and magnet bars to incorporate into other robots. SoCalGas could potentially use this new Explorer robot for inspections where there is a risk of liquids in the pipeline improving data quality and inspection performance.	
147	GO118	Plastic Pipeline Inspection for Pipeline Integrity Management (GFO-22-503)	202309082232	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	12/1/2023	8/18/2026	$15,000	$15,000	$0	$15,000		Active		SCG $15,000 | CEC $999,319 | Others $596,394	Operational Efficiency, Improved Affordability, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results	The objective of this project is to demonstrate the probability of detection of different categories of anomalies in plastic pipe assemblies when using Phased Array Ultrasonic Testing (PAUT) non-destructive evaluation (NDE) tools for inspecting both plastic pipe and fusion joints. The most common modes of material failure for polyethylene piping systems are slow crack growth and non-ductile fusion joint failure, and current NDE methods for plastic piping are not as well developed as they are for steel piping systems. This project will also identify the correlation of expected residual lifetimes for assets, given the indication of defect, by utilizing the information provided by NDE inspections allowing for input into the risk assessment models. The project will focus on extensive testing of a relatively mature PAUT tool capable of identifying cracks in pipe walls and defects in fusion joints. The fieldwork will be supported by extensive laboratory testing aimed at verification of inspection results and accelerated lifetime testing of the pipe assemblies where indications of defects may be identified. If the results are fruitful, SoCalGas will deploy the technology to enhance the safety of plastic pipelines by introducing new NDE inspection tools for both plastic pipe and fusion joints.	
148	GO119	Selective Seam Weld Corrosion Detection with In-line Inspection Technologies (NDE-4-13)	202009282175	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	10/6/2020	6/30/2024	$34,713	$810,000	$34,713	$0		Active		SCG $34,713.00 | PRCI Members $775,287.00	Reliability and Safety	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Technology & Knowledge Transfer/Training	The objective of this project is to evaluate and validate magnetic flux leakage (MFL) technologies currently in use by In-Line Inspection (ILI) vendors for detecting selective seam weld corrosion (SSWC). SSWC is a type of corrosion that affects the bond-line region and heat-affected zone of the longitudinal seam of a pipeline, forming grooves in the seam. Circumferential MFL technologies can detect the long-seam weld position and accurately detect the presence of corrosion on the long seam. However, these MFL tools generally cannot differentiate between SSWC and coincidental corrosion. As technologies and analysis processes have improved, ILI vendors are now better able to detect SSWC. This project will provide pipeline operators with up-to-date knowledge about ILI capabilities to detect SSWC and differentiate it from coincidental corrosion interacting with the long seam weld. This knowledge will help them make informed decisions about managing pipelines with SSWC or corrosion. In 2022, the vendor completed acid etching to create test samples with SSWC and corrosion. They delivered documentation that addresses raised edges of electrical discharge machined (EDM) notches and adjacent corrosion. SoCalGas can use this research's results and identified tools to detect SSWC in its pipelines better, thereby improving safety and reliability.	
149	GO120	Sensing Liquid Accumulation in Mains (OTD 5.24.e)	2024012421638	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	12/1/2023	12/1/2024	$20,000	$100,000	$0	$20,000		Active		SCG $20,000 | OTD Members $80,000	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish results	The objective is to identify non-contacting, level-sensing technology that could be used in natural gas systems to detect liquids. Utilities install drips to collect liquids, so customers are not impacted. A low-cost system is needed to alert the utility of liquids levels in near real-time, and this project is the first step toward this goal. The project team will test and verify the identified sensors in the laboratory. The sensor testing results and a reference design for a field system will be provided that could be incorporated into a remote monitoring system in the project's next phase. The project tasks include: 1) identifying commercially available level-sensing/ranging sensors, 2) bench-testing a selection of the sensors, 3) performing an analysis of the data to determine the accuracy and whether the sensor is a viable option for this use case, and 4) developing a field prototype design for sensor(s) passing testing. SoCalGas is anticipating that the field-deployable sensor system will be demonstrated at its test facility, and, if the test is successful, will be evaluated for possible deployment. The project benefits are expected to be reduced costs and improved reliability of service to ratepayers.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
150	GO121	Subsidence Study	20220720212647	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/25/2022	4/28/2023	$17,200	$17,200	$17,200	$0		Completed		SCG $17,200.00 | None $0.00	Reliability and Safety	Early Stage (TRL 1-3)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	This project will perform analytical modeling to estimate levels of relative displacement between a transmission pipeline and five tap locations, validating the results of earlier studies. Buried natural gas pipelines can be damaged by soil displacement resulting from sudden extreme events, such as floods, landslides, earthquake fault rupture, and gradual ground deformations caused by land subsidence. Causes of vertical or horizontal land subsidence include extraction of water, oil, or gas; sinkholes; mining activities; and natural consolidation. A previous study evaluated the potential hazard to natural gas transmission pipelines from subsidence resulting from water withdrawal in the San Joaquin Valley. The results supported the conclusion that long-term subsidence from water withdrawal does not pose a significant threat to steel gas transmission pipelines at general locations. However, the study concluded that relative axial displacements at some tap locations could be a concern in the future. The study recommended that efforts be taken to discern if there are signs of relative displacement or distress at tap points identified as having the largest relative axial displacements. The project tasks include modeling a section of transmission pipe and five tap locations and analyzing various scenarios affecting tensile and compressive strain as a function of axial displacement. The team will perform the analyses using simulation software with typical pipe elements and non-linear springs to represent soil restraint. This study could help to pre-emptively manage the subject tap locations and significantly reduce the need for costly mitigative measures to repair or replace damaged pipeline sections due to subsidence displacements.	
151	GO122	Technology Development Center (TDC-1-1 & 1-A)	SCG1540077	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	1/1/2015	12/31/20234	$42,709	$3,440,727	$42,709	$7,358		Active		SCG $42,709 | PRCI Members $3,398,018	Reliability and Improved Affordability	Late Stage (TRL 7-9)	•Field Demonstration/Validation Testing	This project provides support for the new Pipeline Research Council International Technology Development Center (TDC) in Houston, Texas which opened in the summer of 2015. The TDC is the result of a major commitment by the energy pipeline industry to address the key issues the industry is facing to ensure the safety and integrity of the vital national and international steel pipeline infrastructure. The TDC provides the industry with an independent third-party site to thoroughly describe the capabilities of current pipeline inspection tools and to guide the development of new technologies needed to push toward the pipeline safety and integrity goal. The TDC enables efficient and timely access to industry samples in support of technology projects and programs. In 2021, The TDC was utilized by PRCI projects, for example NDE-4-18 Validate ILI Capabilities to Detect/ Characterize Mechanical Damage. .	
152	GO123	Tools and Methods to Assess Pipe Mate	20220811192355	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	7/28/2022	7/31/2023	$15,265	$59,000	$15,265	$0		Completed		SCG $15,265.00 | PRCI Members $43,735.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; Deployment of Results; Share/Publish Results	The objective of this project is to perform a State-of-the-Art literature review of existing in-line inspection (ILI) and in-ditch tools to identify techniques with the potential to inspect the mechanical properties of steel pipe without the need for excavation. Technology companies have made a significant effort to develop in-ditch tools to measure mechanical properties. However, these technologies are used on the external surface of the pipeline and require exposure. An in-line tool option that characterizes mechanical properties, including fracture behavior and metallurgical properties, would be invaluable in confirming maximum allowable operating pressure (MAOP) and allow operators to approve these pipelines for hydrogen transport. This project will: 1) identify technologies that exist in the public domain from a variety of sources, including: ILI service providers, sensor, and surface hardness technology companies; 2) assess the status of each of the technologies from various sources and potential for application onto in-line tools; 3) evaluate and analyze the findings; 4) discuss technologies that exhibit potential; and 5) develop a comprehensive report summarizing the findings. SoCalGas could benefit from this project because obtaining precise information regarding pipe material properties is essential for MAOP verification and understanding the impacts of hydrogen blending on the transmission pipeline system. Additionally, this project could provide an option to gather information on pipeline materials at a lower cost due to excavation not being required, which will support SoCalGas in meeting pipeline regulations for integrity management.	
153	GO124	UCLA Monitoring and Risk Assessment for Natural Force Damage to Pipelines (GFO-22-503)	2023090822018	Gas Operations	System Inspection & Monitoring		GeoHazard Threat Inspection and Monitoring	12/1/2023	10/31/2024	$15,000	$3,964,749	$0	$15,000		Active		SCG $15,000 | CEC $2,992,909 | Others $956,840	Reliability, Safety, Operational Efficiency	Late Stage (TRL 7-9)	Further Technology Development/Prototype; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to mature the seismic risk assessment software tools developed under the past CEC-funded project, “Seismic Risk Assessment and Management of Natural Gas Storage and Pipeline Infrastructure in CA (PIR-8-002),”, by adding various data obtained from monitoring technology, including satellites, LiDAR, fiber optics, and pipeline sensors. The project will also use ground- motion measurements to predict pipe strain support, which can be used to expand and update the fragility database to combine direct and indirect measurements. The project will update the software platform created in project PIR-18-002 to work in near- real-time data and to provide training to California gas operators and industry partners on how to use the software. SoCalGas will use the results of this project to cover a wider range of ground motion scenarios and perform near real-time risk assessment based on reading field data which can reduce the risk of pipeline failure caused by natural hazards.	
154	GO125	Underground Natural Gas Storage and Risk of Corrosion/Souring (7.22.i)	20230711214133	Gas Operations	System Inspection & Monitoring		Corrosion Inspection and Monitoring	12/1/2023	7/31/2025	$31,724	$441,732	$0	$31,724		Active		SCG $31724.00 | OTD Members $410,008.00	Safety, Operational Efficiency, and Improved Affordability	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to better understand the risk and opportunities of microbial-hydrogen interactions in a storage reservoir. The project will focus on pure and natural-gas-blended hydrogen storage in the three commonly used storage types, aquifers, depleted hydrocarbon reservoirs, and salt caverns. The work will include 1) laboratory experiments simulating reservoir conditions using high-pressure bioreactor systems to collect data on changes in gas composition and microbial activities and 2) chemical and microbial analysis of the data. The deliverable will be a final report. In 2023, the project team held a kick-off meeting to identify field test sites and the associated reservoir parameters, temperature and pressure range. SoCalGas will provide field samples from at least two SoCalGas storge fields. The next step is to collect the field samples. The project team intends to use clean, renewable hydrogen for the laboratory tests. SoCalGas anticipates using the results of this research to identify solutions to manage integrity risks. SoCalGas will also use this research to gather information regarding the potential loss/conversion of hydrogen in a storage reservoir.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) The hydrogen blending pilot projects do not include underground storage. 2) The project will research the impact on pure and natural gas blended hydrogen on underground storage. SoCalGas has requested the use of clean renewable hydrogen to be included this projects scope.
155	GO126	Validate In-Line Inspection (ILI) Capabilities to Detect/Characterize Mechanical Damage (PHMSA) (NDE-4-18)	2020020622476	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	9/30/2019	12/31/2023	$25,722	$3,012,542	$25,722	$0		Completed		SCG $25,722.00 | PRCI Members $2,986,820.00 | PHMSA $1,397,722.00	Reliability and Safety	Mid Stage (TRL 4-6)	Technology & Knowledge Transfer/Training	This project expands the current state of knowledge for In-Line Inspection (ILI) system performance to detect and characterize corrosion, welds, gouges, and crack features interacting with dents. The project will generate data to support the Pipeline Research Council International’s (PRCI) research and development projects pursuing the development of revised dent response criteria. Additionally, it will address recommendations issued to Pipeline and Hazardous Materials Safety Administration (PHMSA) by the National Transportation Safety Board to promulgate new regulations that address dent acceptance criteria. In 2022, four vendors performed trial runs with their tools through mechanical damage test strings built at PRCI’s Technology Development Center. The systems employed mechanical calipers and ultrasonic technologies for dent geometry. Ultrasonics were also used for metal loss and crack identification and sizing. The team used Magnetic flux leakage technology for metal loss. All vendors performed trials at multiple speeds, and they duplicated some of the speeds to collect various data sets, which they used to show repeatability and consistency, as well as provide backup data. The post-processing analysis is still pending, so PHMSA approved a project extension into mid-2023. The next steps are to finalize the data analysis and potentially perform more pull tests. SoCalGas can benefit from this research if the project results in revised dent response criteria based on engineering knowledge of the pipe conditions. It can then target excavation to pipe segments that meet the revised response criteria.	
156	GO127	Validation of NDT Technology for PE Pipe (5.20.p)	20201023181952	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	10/1/2020	4/30/2024	$17,054	$200,000	$17,054	$0		Active		SCG $17,054.00 | OTD Members $182,946.00	Reliability and Safety	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing	In this project, the team is evaluating the claims of commercially available nondestructive testing (NDT) technologies for polyethylene (PE) pipe and fitting joints. This evaluation includes heat fusion (e.g., butt and sidewall) and electrofusion (e.g., couplings, service tees, etc.) pipe joining methods. Industry stakeholders need to understand the capabilities and limitations of the various NDT technologies to determine whether the technologies are reliable for determining joint integrity. Previously, the team gathered information on sponsors’ current use of NDT technologies on PE fusion joints with a survey. The project team held a workshop with stakeholders to review the capabilities of existing NDE technologies and to develop a roadmap for the next steps in evaluating them. Following the roadmap developed by stakeholders in the workshop, the types of test samples were chosen. Several NDT technology vendors have shown interest in participating in this study. Based on recent project team communications with vendors and the methods they use, however, it was determined that appropriate acceptance criteria for test samples should first be developed. In 2022, the project team worked on revising the project scope to include developing acceptance criteria, upgrading the control software on the butt-fusion machine that is used for the project, and preparing butt-fusion samples for testing. Once the project is completed, the team will deliver a final report detailing the NDT technologies identified, the validation test results, and supporting documentation for each pipe joining method, NDT technology, and NDT vendors. Additionally, the team will identify potential technology enhancements that would make the NDT technology for PE pipe more reliable.	
157	48	ZEI Harbor Craft Demonstration	20201014173330	Clean Transportation	Off-Road		Off-Road	1/1/2021	12/31/2025	$198,938	$3,400,116	$148,938	$50,000	$0	Retired	$25,000	CEC - $2,000,000 Ocean5 Naval Architects - $15,158 ZEI - $1,186,020	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	In this California Energy Commission funded project, Golden Gate Zero Emission Marine (GGZEM) aims to develop and demonstrate a small, fast, hydrogen fuel cell powered, rigid inflatable boat for a variety of harbor craft use cases. GGZEM further proposes to develop and deploy supporting mobile and portable hydrogen fueling solutions. GGZM will demonstrate the vessel for six months in San Francisco Bay and Long Beach harbor. The project team will integrate a hydrogen fuel cell used by the automotive industry with a small, approximately 25-foot,commerically available rigid inflatable boat. Vessels under 40 feet in length have a wide variety of uses, including patrol, fire and rescue, fishing, pilot, excursion, ferry and taxi, and recreation. Developing a zero-emission hydrogen fuel cell vessel could help reduce emissions and improve air quality in and around harbors and ports. The vessel will be fueled through novel mobile, portable systems developed by GGZEM for marine vessel fueling and built through the project, using hydrogen sourced from California’s retail hydrogen stations. GGZEM will apply their knowledge and experiences from the existing CARB funded 84-passenger hydrogen ferry project to this development. The project contracting was wrapped up in 2021, and work will commence in early 2022. .	
158	49	GTI Hydrogen Fuel Cell Switcher Locomotive Demonstration	20201014172728	Clean Transportation	Off-Road		Off-Road	1/1/2021	12/31/2025	$537,500	$5,964,876	$358,333	$179,167	$0	Retired	$150,000	CEC - $3,999,971 LCRI - $324,000 Sierra Northern Railway - $573,405 SMAQD - $500,000 Ballard - $30,000	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	GTI and Sierra Northern Railway will design, build, and demonstrate a hydrogen fuel cell, zero-emission, switcher locomotive in the seaport of West Sacramento. The project was awarded funding by the California Energy Commission’s (CEC) Grant Funding Opportunity GFO-20-604: Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports (H2RAM), Group 1: Fuel Cell Demonstrations in Switcher Locomotives and Commercial Harbor Craft. Sierra Northern Railway will replace the diesel engine of a switcher locomotive with a hydrogen fuel cell, eliminating 10,000 gallons of diesel fuel use per year. This will improve local air quality and eliminate corresponding greenhouse gas (GHG) emissions. The locomotive will be demonstrated on Sierra Northern Railway’s short-line operations which serve the railyard and seaport in West Sacramento.. It will remain in service after the demonstration period. The integration of advanced fuel cell and battery technologies represents a new platform that will enable commercialization within a few years. The project is in its earliest stages of activity, and ork is progressing to remove legacy diesel drivetrain, to design the fuel cell integration, and to acquire equipment for integration. .	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
159	50	CTE Fuel Cell Electric Delivery Van Demonstration	2021100115636	Clean Transportation	On-Road		On-Road	11/1/2021	12/31/2024	$750,000	$15,229,320	$500,000	$250,000	$309,356	Retired	$75,000	CARB - $4,302,896 CEC - $744,755 DOE - $2,982,081 2,982,071 SCAQMD - $980,000 UPS - $5,469,588 5,378,490	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	The Center for Transportation and the Environment (CTE) will develop and demonstrate 15 fuel cell electric delivery vans with UPS in Ontario, CA. Currently, there are no hydrogen fuel cell medium-duty vehicle for goods movement. UPS's existing battery electric fleet vehicles meet approximately 70% of UPS route range requirements. When configured with the fuel cell electric propulsion system being deployed by this project, the vehicle is expected to meet almost 95% of UPS service needs. The project will show that a van with UES's propulsion system can provide fleet operators with a zero-emission vehicle capable of meeting route range requirements while matching the performance characteristics of its existing fleet vehicles. According to Fleet DNA data compiled by the National Renewable Energy Laboratory (NREL), a vehicle with a 125-mile range will meet 97% of Class 3–6 daily delivery driving distances. Meeting CARB's desired 150-mile range threshold increases the attractiveness of zero-emission trucks to fleet operators and increases the commercial viability of fuel cell electric conversion kits. All fifteen fuel cell vans will be operated in routine UPS service for at least 5,000 hours of operation. During this period, maintenance and operational support will be provided by the Project Team. Throughout the period, all required operational data will be collected and reported. .	
160	51	Cummins Integrated Fuel Cell Electric Powertrain Demonstration	20201201205442	Clean Transportation	On-Road		On-Road	3/31/2020	12/31/2025	$240,000	$3,764,624	$24,000	$216,000	$0	Retired	$80,000	Cummins - $1,484,390 DOE - $1,797,984 Navistar - $195,000 SCAQMD - $47,250	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	Cummins will develop and demonstrate a modular scalable fully integrated heavy duty fuel cell prototype design to be tested in a Class 8 Truck. Data will be collected and analyzed by CALSTART. The HD Class 8 truck demonstration will utilize a Cummins HD architecture with two fuel cell engines. Each of the engines consists of two stacks that together produce 90kW of power. The overall goal of the project is to demonstrate the feasibility of this modular scalable platform that utilizes a plug and play design for ease of installation as shown in the adjacent picture. The project seeks to demonstrate that the truck meet a 300+ mile range and exceed the current mileage limitations of pure battery electric HD vehicle solutions. The fully integrated powertrain that includes the fuel cell, battery, motor, inverter, and optimized controls will be installed as a vertically integrated solution to allow for overall cost reductions. The project team proposes to demonstrate the truck in Southern California.	
161	51-2	A1 Alt Fuels Fuel Cell Electric Paratransit Shuttle Demonstration	20210520161416	Clean Transportation	On-Road		On-Road	5/20/2021	4/30/2025	$531,166	$2,086,608	$516,166	$15,000	$0	Retired	$10,000	SCAQMD - $531,166 A1 - $132,668 US Hybrid - $508,000 Luxfer - $28,000 Sunline Transit - $160,608 Turtle Top - $85,000 Hometown - $110,000	Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	A1 Alternative Fuel Systems will develop and demonstrate two fuel-cell electric vehicles at Sunline Transit and Golden Empire Transit for 12 months. The vehicles include two class 4 medium paratransit shuttles, a low-floor (kneeling) Ford F-53, and a standard-floor Ford E-450s. The paratransit shuttles will be capable of a 175 – 250 mile range per fill. In addition to the demonstration, A1 Alternative Fuel Systems will test and certify the shuttles at the Altoona Test Center and for CARB on-road use. This project will help shuttle and transit fleets meet the California Zero Emission Bus Regulations and upcoming California Zero Emission Truck regulations within the required time frame. The team has developed the high-pressure fuel cell system used for the shuttle to easily integrate into other vehicle types that useintegrate into other vehicle types using the same Ford chassis. Ford's innovative design allows fleet operators to order a factory-built Ford cab and chassis, which they can configure as a wide variety ofvarious vehicle types, such as delivery trucks, work trucks, shuttles, and vans.	
162	51-3	CALSTART Hydrogen Zero Emission Tugboat Design	20201014173141	Clean Transportation	Off-Road		Off-Road	1/1/2021	2/29/2024	$100,000	$623,309	$100,000	$0	$0	Retired	$0	CEC - $498,309 CALSTART - $25,000	Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Early Stage (TRL 1-3)	Seek funding to build prototype	CALSTART has assembled a consortium of leading maritime stakeholders to design a hydrogen fuel-cell-powered zero-emission tugboat and support plans for refueling infrastructure. The consortium includes the following industry leaders: DNV-GL, ABB, Ballard, Chart, Crowley, Jensen, the Port of Los Angeles, and the South Coast Air Quality Management District. This project was awarded CEC grant funding through GFO-20-604: Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports (H2RAM) solicitation for Group 3: Design and Feasibility Study of Fuel Cell-Powered Commercial Harbor Craft. Tugboats are an essential component of port operations. Tugboats assist cargo vessels, tankers, and barges in and out of port complexes and play a role in other applications, such as firefighting. Tugboats have extreme power-tonnage ratios, typically two to four times that of normal cargo or passenger ships, and often feature two of each critical part for redundancy. They are highly maneuverable and currently use diesel engines that produce anywhere from 600 hp to over 20,000 hp and consume over 15,000 gallons of diesel fuel per month. A zero-emissions tugboat will advance state and national greenhouse gas emission reduction goals. To achieve the project objectives, the team will develop a design for a fuel cell-powered tugboat that they will use to inform future production and deployment. The team will also assess the economic feasibility, conduct a cost-benefit analysis, identify technology and regulatory barriers to using hydrogen in the maritime industry, and develop plans for the necessary refueling infrastructure – including hydrogen production and delivery pathways.	
163	51-4	Frontier Energy MC Formula Protocol for H35HF Fueling Demonstration	20201109191041	Clean Transportation	Refueling Stations		Refueling Stations	1/1/2021	2/29/2024	$80,000	$705,000	$80,000	$0	$0	Retired	$0	DOE - $545,000 Shell - $20,000 SCAQMD - $25,000 Luxfer - $20,000 Sunline Transit - $10,000 Frontier Energy - $5,000	Reliability, Public and Employee Safety, Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Publish standard	This project will develop and test the MC Formula method for fueling heavy-duty-hydrogen-fuel-cell trucks at 5,000 psi using H35HF (high flow) dispensers. The MC Formula Method is a lumped heat capacitance model that calculates end-of-fill gas temp. Hydrogen refueling stations and protocols are responsible for safely fueling any hydrogen-fuel-cell vehicle. Commercial hydrogen refueling stations use the SAE J2601 Lookup Table (LT) method with limited temperature and pressure boundaries to safely refuel vehicles. The MC Formula method uses the actual pre-cooling temperatures of the dispenser as the control input. A key difference between the LT and MC methods for refueling is that the LT method uses feed-forward static controls while the MC method uses dynamic feedback controls. This method allows for high-flow scenarios and faster and more accurate filling of fuel cell vehicles.	
164	51-5	GTI CNG Plug-In Class 8 Hybrid Truck Development and Demonstration	20200117202314	Clean Transportation	On-Road		On-Road	11/1/2019	3/31/2024	$161,250	$1,765,438	$161,250	$0	$0	Retired	$0	CEC - $1,499,381 US Hybrid - $31,157 CWI - $53,650 SCAQMD - $20,000	Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	The goal of this project was to design, develop, and demonstrate a prototype control system integrated into a Natural Gas (NG) – Hybrid Electric Class 8 truck, optimized to achieve both near-zero oxides of nitrogen (NOx) emissions and significant greenhouse gas (GHG) savings. The vehicle used a 239kW 8.9-liter near-zero natural gas engine, a 222kW electric motor, a 31kWh lithium-ion battery pack, and electric accessories to provide equivalent performance to a larger 15-liter diesel engine while adding a 20-mile zero-emissions range. By comparing the emissions test results to engine emissions tests on similar platforms, the research team found that a hybridized near-zero powertrain can offer a 36% improvement in fuel economy and NOx emissions 22x lower than the current 0.02g/bhp-hr standard. Moreover, the team has found that 90% of NOx emissions are attributed to cold-start operations. Further research, optimization of the system, and support from the component manufacturers could yield additional improvements and offer NOx emissions rivaling well-to-wheel emissions of battery-electric vehicles. However, the NG HD-HEV technology would provide the range, reliability, and refueling convenience advantages over battery-electric alternatives. The team recommends further refinement and deployment of this technology, and they issued the final report to the CEC in Q4 2022.	
165	51-6	GTI CNG Smart Station Demonstration	2018102634	Clean Transportation	Refueling Stations		Refueling Stations	1/31/2019	3/31/2024	$268,754	$3,037,049	$255,316	$13,439	$0	Retired	$13,439	DOE - $2,040,384 CEC - $532,218 UT-CEM - $195,693	Reliability, Public and Employee Safety, Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Advance prototype	This project aims to address natural gas vehicle total cost-of-ownership by developing and demonstrating a smart fueling system that includes a full suite of necessary technologies that enable consistent full fills of natural gas vehicles. These technologies include a smart vehicle and dispenser, an advanced full-fill algorithm, and cost-effective gas pre-cooling using a near-isentropic-free piston expander and compressor. This combination of technologies solves the technical challenges of dispensing uncertainty and compression heat, resulting in underfilled natural gas vehicles. By eliminating under-filling, it may be possible to reduce the CNG fuel system's volume, weight, and cost by approximately 25% while increasing fuel economy, cargo capacity, safety, and driver experience. The GTI Energy and University of Texas Center for Electromechanics (UT-CEM) project team will perform system design, testing, and techno-economic analysis.	
166	51-7	GTI Energy Advanced On-board Hydrogen Storage Technology Assessment	20221106195154	Clean Transportation	Onboard Storage		Onboard Storage	11/28/2022	6/30/2024	$225,000	$225,000	$225,000	$0	$0	Retired	$0	N/A	Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Share information	This project aims to identify and test state-of-the-art onboard hydrogen storage technologies for transportation. Current vehicle hydrogen storage consists of high-pressure gaseous hydrogen, which requires a high volume to achieve the required runtimes. This project will be conducted in two phases. In Phase 1, GTI Energy will conduct a market assessment of advanced onboard storage technologies. This market assessment will identify the most promising state-of-the-art technologies to be evaluated in Phase 2. In Phase 2, following the market assessment, GTI Energy will evaluate, analyze, and support the technical development of three advanced onboard hydrogen storage technologies. These technologies are important for advancing fuel-cell electric vehicles because fuel storage systems are typically the largest individual cost component. Developing these technologies could yield the following benefits: increased volumetric energy density, reduced storage vessel costs, lower weight, resulting in increased payload and improved fueling efficiency.	
167	51-8	GTI Energy Cost-Effective Pre-Cooling for High-Flow Hydrogen Fueling Development	2021102715484	Clean Transportation	Refueling Stations		Refueling Stations	12/19/2022	12/31/2024	$268,750	$2,783,098	$150,000	$118,750	$0	Retired	$50,000	DOE - $2,197,984 UTD - $180,000 GTI Energy - $136,364	Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Advance prototype	This project aims to develop a high-flow pre-cooling system suitable for heavy-duty hydrogen fueling applications. The design will target the most cost-effective pre-cooling method possible by using commercially available components. The team will design the system to achieve the DOE target of 6 minutes, or 10 kg/min average fueling rate. Current chillers require more than 300kw of power. This project will target a peak power consumption of less than 200kW. The team will execute the project in three phases: 1) preliminary design, 2) sub-scale prototype development and economic analysis, and 3) performance testing of the sub-scale system, economic analysis updates, and commercialization plan. The team has identified and included performance and economic metrics in stage gates between phases. By the end of the project, the team targets having a performance-validated full-scale chiller design and commercialization plan in place with a manufacturing partner.	
168	51-9	GTI Energy H2 at Scale Hydrogen Refueling Demonstration	20200117201722	Clean Transportation	Refueling Stations		Refueling Stations	11/1/2019	12/31/2024	$483,750	$11,287,021	$483,750	$0	$0	Retired	$0	DOE - $5,400,000 Industry Partners - $5,403,271	Reliability, Public and Employee Safety, Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Share information	The H2@Scale project has two unique research, development, and demonstration tracks to understand better the potential of integrating hydrogen with multiple platforms throughout the economy. First, the project will include the demonstration of co-located multiple hydrogen generation and end-use applications at the University of Texas, Austin. Activities include 100% renewable hydrogen generation (steam methane reforming and electrolysis), a 100kW fuel cell powering a data center, and vehicle and drone refueling. In the second track, the project will leverage the experience from this demonstration and research and outreach to develop a framework for additional H2@Scale pilot opportunities.	
169	51-10	GTI Energy Symbio Class 8 Long-Haul Hydrogen Fuel Cell Truck Demonstration	20220111233238	Clean Transportation	On-Road		On-Road	11/1/2022	12/31/2024	$500,000	$5,148,158	$300,000	$200,000	$247,485	Retired	$35,000	CEC - $1,999,667 Symbio - $1,190,277 Michelin - $120,000 Faurecia - $820,214 TTSI - $318,000 UTD - $200,000	Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	The project aims to design, develop, and demonstrate an advanced hydrogen fuel-cell class-8 truck operating on a 400-mile route between Fontana and Lathrop, California, along the I-5 corridor in the San Joaquin Valley. The truck will match the performance of a 15-liter diesel vehicle utilizing proven pre-commercial core technologies, including a 400kW high power density Symbio fuel cell featuring stainless steel stacks, Faurecia's 60+ kg 700bar onboard hydrogen storage, and Michelin's advanced e-tires integrated into a widely adopted Freightliner Cascadia truck. The project intends to demonstrate the feasibility of fuel-cell vehicles on demanding regional haul routes where battery-electric trucks cannot meet the range or operational requirements. The vehicle will be fueled at public hydrogen fuel stations and from a mobile fueler deployed as required at one of the Michelin Commercial Service Networks along the route. The powertrain will handle challenging duty cycles such as the Tejon Pass ("the Grapevine") and extended freeway speeds in the San Joaquin Valley. Over the 12 months, the vehicle will travel over 60,000 zero-emission miles, most of them in disadvantaged communities across 7 California counties. Technical targets include a fuel cell system lifetime of 25,000 hours or 10 years/1,000,000 miles, at least 1.9x fuel economy improvement over equivalent internal combustion engine-powered vehicles, and total cost of ownership reduction of at least 30% compared to current fuel cell technology. The team will conduct a techno-economic analysis to compare the TCO of the next-generation fuel cell truck to existing technology.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
170	51-11	Immaterial Low-Cost Liquid Hydrogen Boil-Off Capture and Utilization Assessment	20220107195735	Clean Transportation	Refueling Stations		Refueling Stations	1/1/2022	12/31/2023	$245,572	$245,572	$245,572	$0	$118,263	Completed	$0	N/A	Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Early Stage (TRL 1-3)	Seek demonstration opportunities	Immaterial, a research, experimental development, and engineering firm built at the University of Cambridge (UK), has a unique technology, providing a step-change in the performance of Metal-Organic Framework (MOF) materials. This project aims to develop a computational fluid dynamics model of a cryo-adsorbed hydrogen boil-off management system and initial demonstration design. Simultaneously, Immaterial will develop second-generation optimized materials for boil-off conditions and a high-level techno-economic model. Immaterial will also identify target applications for their MOF technology. Boil-off – a phase change from liquid to gas – occurs when fluid, in this case, liquid hydrogen (LH2), is warmed by the energy transfer with the environment during vessel-to-vessel transfer. Boil-off is common along the LH2 supply chain, including vehicle refueling. Using MOFs to capture hydrogen boil-off can help reduce GHG emissions by capturing and using this otherwise wasted hydrogen. This approach can improve total costs by reducing hydrogen losses. First-generation Immaterial MOFs have demonstrated world-leading volumetric capacity, reaching storage capacities of 45g/L at 25 bar and 77 K as validated by the National Renewable Energy Laboratory. This strategy is already a 22% enhancement over the DOE record of 37 g/L at 100 bar and exceeds the current EU Horizon target of 40 g/L at 100 bar.	
171	51-12	Sandia National Labs Metal Hydride Composite Hydrogen Storage for Heavy Duty Vehicles	20200713155311	Clean Transportation	Onboard Storage		Onboard Storage	11/30/2020	2/29/2024	$575,000	$1,875,000	$575,000	$0	$0	Retired	$0	DOE - $1,300,000	Reliability, Public and Employee Safety, Operational Efficiency, Improved Affordability	Mid Stage (TRL 4-6)	Seek demonstration opportunities	This project aims to evaluate metal hydride composites as a materials-based storage medium to replace high-pressure hydrogen gas storage on Class 7 and 8 heavy-duty fuel cell electric trucks. The thermodynamic and kinetic properties of metal hydrides allow them to regenerate fully following hydrogen desorption at pressures much lower than 700 bar. For example, metal amides considered in this project can be revived at 100 bar, much lower than current onboard high-pressure hydrogen storage tanks (350 bar or 700 bar). Lower-pressure hydrogen could translate into more efficient storage tank designs that weigh and cost less than current high-pressure steel hydrogen storage tanks. Low-pressure hydrogen for vehicles can also increase reliability and reduce compression costs at refueling stations by utilizing lower-pressure compressors. An additional benefit is that knowledge generated by this project could assist in developing material-based storage for stationary applications such as microgrids and backup power for data centers. Sandia National Laboratory is still conducting its analysis. The team expanded the scope to include exploring material-based hydrogen storage for rail.	
172	51-13	SCAQMD and WVU Alternative Fuel Vehicle Maintenance Study	2020041519396	Clean Transportation	On-Road		On-Road	1/1/2020	3/31/2024	$150,000	$1,335,682	$150,000	$0	$0	Retired	$0	DOE - $1,085,682 SCAQMD - $100,000	Reliability, Improved Affordability	Foundational Research (Pre-TRL)	Share information	This project aims to study maintenance-related efforts and costs of medium- and heavy-duty vehicle engines powered by various alternative fuels across multiple vocations. The alternative fuels considered in this study are natural gas, propane, electric, and high biodiesel blends. This maintenance cost assessment incorporates the link between the operational characteristics of alternative fuel vehicles and how they affect maintenance and repair activity. The team will also perform a comparative evaluation of vehicle maintenance costs between natural gas and diesel-fueled vehicles. Vehicles included in the analysis are Class 6, 7, and 8, which the industry often uses in goods movement and delivery vocations. The project team will use vehicle maintenance costs of available fleet information, real-world vehicle activity, and in-use emissions data from another study upon which this project builds. The team will further leverage emissions and activity data previously collected and pre-established relationships from previous research.	
173	51-14	SCAQMD Ford 7.3L Near-Zero Emission Engine Development	2019092516423	Clean Transportation	On-Road		On-Road	11/30/2019	12/15/2023	$320,413	$3,021,247	$320,413	$0	$0	Completed	$0	SCAQMD - $619,588 Landi Renzo - $855,072 Agility Fuel Systems - $1,226,175	Reliability, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	This study aims to develop and commercialize the Ford 7.3L compressed natural gas (CNG) near-zero emission (NZE) Engine for medium-duty trucks. Widely untapped, the medium-duty truck market has not seen any near-zero-emission engines available other than the Cummins Westport, Inc. ISB 6.7 engine. The original plan was for three companies to develop and test engines. However, only one company, Agility Fuel Solutions, completed the project. Agility completed the development and certification process as of the summer of 2022. Agility developed all the hardware required to operate the Ford 7.3L engine on CNG and LPG fuel. After successfully demonstrating the ability to achieve a 0.02 g/bhp-hr NOx needed to meet the Low NOx standard requirements, Agility applied for certification with the US EPA and CARB. Additional testing showed the ability to meet 0.01 g/bhp-hr NOx using only engine calibration and OEM Ford exhaust systems. Durability testing was also performed, which demonstrated that Agility's modifications do not cause the Ford 7.3L engine to exceed any of Ford's established durability limits or not exceed thresholds. These are the first medium-duty class engines to reach near-zero emissions and will likely be widely adopted into Ford medium-duty truck platforms.	
174	51-15	SCAQMD Hydrogen Blended Natural Gas in NZE Engine Emissions Study	20191014214310	Clean Transportation	On-Road		On-Road	11/21/2019	9/30/2024	$304,000	$534,000	$304,000	$0	$0	Retired	$0	SCAQMD - $232,000	Reliability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Seek demonstration opportunities	This research aims to provide data to justify the initiation of extensive validation work to increase the hydrogen limit for near-zero emission natural gas engines. This research project assesses the criteria pollutant and greenhouse gas impacts of hydrogen-natural gas fuel blends on near-zero NOx emission heavy-duty natural gas engines. Past studies have shown that adding hydrogen to natural gas may reduce engine emissions when combined with optimized engine calibration. The University of California Riverside's Center for Environmental Research and Technology will design and build a hydrogen-compressed natural gas (H-CNG) blending apparatus as part of the study and vary hydrogen content from zero to five percent by volume. The study's first phase focused on the emissions impacts of H-CNG blends compared to the baseline on regulated engine test duty cycles. CWI provided the test engine, after-treatment systems, engineering, data analysis support, and oil sample analysis. A 2005 comprehensive study by the National Renewable Energy Laboratory showed that an H-CNG-fueled engine reduced NOx emissions by 50 percent compared with a CNG-fueled engine in a transit bus application. Recent low-carbon and renewable fuel initiatives have renewed interest in further decarbonization of natural gas, providing a source of lower carbon content fuel for the transportation sector.	Yes
175	51-16	UC RIverside Hydrogen Blended Natural Gas Engine Durability Test	20200306212852	Clean Transportation	On-Road		On-Road	3/6/2020	9/30/2024	$364,977	$489,977	$364,977	$0	$0	Retired	$0	PG&E - $125,000	Reliability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Seek demonstration opportunities	This project aims to evaluate the impact of hydrogen content in natural gas on the performance and durability of one end-use technology, the Cummins L9N 8.9 liter near-zero natural gas engine. Cummins has a set limit for hydrogen content of 0.03% by volume, a long-standing limit probably based on typical natural gas composition. Since the limit is part of the Cummins specification, using natural gas with a hydrogen content greater than 0.03% could void the engine's warranty. The University of California, Riverside research team will operate the motor on hydrogen blended natural gas for 500 to 1,000 hours, simulating normal heavy-duty truck and transit duty cycles. After completing the 500 to 1,000 hours of testing, the research team will disassemble the engine to identify and analyze impacts on the components, fluids, and performance. The research will provide data to justify the initiation of extensive validation work to increase the hydrogen limit for near-zero-emission natural gas engines. Increasing the hydrogen limit in CNG engines will help reduce CO2 emissions.	Yes
176	51-17	US Hybrid CNG Plug-In Hybrid Electric Truck Demonstration	20200309182917	Clean Transportation	On-Road		On-Road	3/31/2020	3/31/2024	$250,000	$3,233,836	$250,000	$0	$0	Retired	$0	CEC - $1,135,000 SCAQMD - $500,000 DOE - $359,137 US Hybrid - $859,699 Clean Energy - $130,000	Reliability, Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	The objective of this project is to develop and demonstrate an advanced Plug-In Hybrid Electric Truck (PHET) powertrain with an existing Cummins Westport Inc (CWI) L9N Near-Zero Emission (NZE) Compressed Natural Gas (CNG) engine on a Freightliner Cascadia sleeper-cab truck in a parallel hybrid configuration. The truck was optimized for over 1,000 miles of total range—including 35 miles of all-electric range—along with more than 600 horsepower to accommodate trucks that require more torque and power. The electric motor, coupled with the L9N CNG engine, will exceed the performance of existing 13-liter diesel engines while reducing carbon dioxide and NOx emissions and additional benefits if run on renewable natural gas. The team will use the truck as a demonstrator for fleets and events. The team will complete emissions and performance analysis through dynamometer and road-testing to assess the PHET design's overall advantage and emissions reduction. The truck is currently in operation with a host fleet.	
177	51-18	UTD CNG Dispenser Tank Communication (2.19.G)	2020040112010	Clean Transportation	Refueling Stations		Refueling Stations	9/1/2019	2/29/2024	$40,714	$250,000	$40,714	$0	$0	Retired	$0	UTD Members - $209,286	Reliability, Public and Employee Safety, Operational Efficiency	Mid Stage (TRL 4-6)	Advance prototype	The objective of this project is to design, build, and demonstrate a prototype smart compressed natural gas (CNG) station that includes a smart CNG dispenser and a smart natural gas vehicle (NGV). The team will develop pre-commercial prototype hardware and protocols that enable the vehicle and station to communicate information about the vehicle's fuel system, such as real-time pressure and temperature, tank volume, and age of the CNG fuel system. This approach will allow for safer, fuller fills of NGVs while enabling fleets to track a vehicle's fuel consumption more accurately. The project team has completed the design and bench scale development of a smart dispenser module that can communicate with the smart vehicle to improve full fills and completed lab testing of the smart dispenser components. The team also began the integration of the smart components with GTI Energy's CNG station to conduct testing with precooling to guarantee full fills of CNG vehicles. The team will share the results with UTD members after the project.	
178	51-19	UTD Next Generation NGV Driver Information System (2.20.F)	2021022523347	Clean Transportation	Onboard Storage		Onboard Storage	7/1/2020	2/29/2024	$15,400	$1,030,427	$15,400	$0	$0	Retired	$0	UTD Members - $242,300 Ozinga Bros Concrete - $772,727	Reliability, Operational Efficiency	Late Stage (TRL 7-9)	Pilot deployment	This project aims to develop and demonstrate a next-generation natural gas vehicle (NGV) driver information system that provides an accurate miles-to-empty estimate for the vehicle. This hurdle is particularly challenging in gaseous-fueled cars because the gas experiences a wide range of temperature fluctuations as the pressure changes during fueling and engine operation. UTD's co-funding will leverage the objectives of a separate prime contract award to GTI Energy by the U.S. Department of Energy (DOE) that provides $1,000,000 in federal funds plus $1,000,000 of in-kind partner support. GTI Energy will model the thermodynamics of the vehicle tank(s), the key technical hurdle for this project. Argonne National Lab will adapt a previously developed NGV fleet navigation application to utilize the miles-to-empty data to optimize fleet efficiency. After the DOE project, the team will engage potential commercial partners for licensing opportunities. In 2022, the project team successfully installed and demonstrated a truck's first Driver Information System. Once the display is validated, the team will install the system in 11 more vehicles. The team has also started discussing deployment in a commercial fleet.	
179	51-20	Yankee Scientific Strategies for CNG and Hydrogen Infrastructure Assessment	20210520161637	Clean Transportation	Refueling Stations		Refueling Stations	5/20/2021	3/31/2024	$148,100	$148,100	$100,000	$48,100	$0	Retired	$0	N/A	Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Foundational Research (Pre-TRL)	Share information	Yankee Scientific's goal for this project is to develop technical strategies to incorporate compressed hydrogen refueling capabilities at existing CNG refueling stations. The results of this project will allow for the accelerated deployment of hydrogen-fueled vehicles, thereby enhancing the use of renewable resources, reducing the generation of greenhouse gases, and improving air quality. In addition, this proposed program will support Transit Agencies as they develop strategies to meet the goals of the California Innovative Clean Transit (ICT) Regulations. Yankee Scientific will investigate methods to implement off-the-shelf components or to convert and share existing CNG station equipment for hydrogen refueling. This approach allows fleets to refuel CNG and hydrogen vehicles as they transition to zero emissions. The team will compare the economics of these technologies with tube-trailer transport of hydrogen from regional generation facilities or large industrial hydrogen suppliers. The team will identify strategies for adding equipment to the existing CNG refueling station. These studies will consider installing structures and equipment using standard site construction methods and prefabricated modular add-on systems when applicable. In addition, the team will evaluate each selected strategy's total station conversion and fuel delivery costs and complete a safety assessment. The team will develop recommendations for the best methods for incorporating hydrogen refueling.	
180	51-21	GTI Doosan Hydrogen Drone Demonstration	2020072715360	Clean Transportation	Off-Road		Off-Road	9/30/2020	1/31/2023	$257,062	$257,062	$257,062	$0	$7,734	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Share information	The project's goal was to advance hydrogen use in aviation by demonstrating Doosan Mobility Innovation's (DMI) hydrogen fuel cell drones for various applications. Hydrogen drones offer significant benefits compared to their battery-electric counterparts. DMI's hydrogen fuel cell drones have longer flight times (2 hours) and significantly shorter refueling times. GTI Energy worked with DMI throughout the project to showcase the technology at various conferences, including ACT Expo and CES. The drone was also demonstrated at two SoCalGas facilities and in Austin, Texas, as part of the H2@Scale project. These demonstrations highlighted the drone's extended flight time, efficient fuel tank swapping procedure, package delivery, and ability to conduct various infrastructure inspections. In addition to the demonstrations, GTI Energy also worked with DMI to assess the product design and operational procedures. This analysis included a review of pertinent codes and standards for the safe operation of the drone. GTI Energy presented this project at the Hydrogen and Fuel Cell Seminar in February 2023.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
181	51-22	GTI Energy Hydrogen Fuel Cell Yard Truck Port of Los Angeles Demonstration	20190422151928	Clean Transportation	Off-Road		Off-Road	1/1/2019	6/5/2023	$372,500	$12,017,657	$372,500	$0	$13,302	Completed	$0	CARB - $5,788,335 BAE - $3,005,971 Ballard - $1,000,000 Capacity - $212,043 Frontier - $20,000 HTEC - $50,000 TraPac - $1,568,808	Reliability, Public and Employee Safety, Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Share information, Next-gen vehicle production/commercialization	The goal of this project was to validate the commercial viability readiness of zero-emissions hydrogen fuel cell electric yard trucks operating in a demanding, real-world cargo-handling application. Yard trucks are the largest source of emissions across all cargo handling equipment classifications. This project aimed to demonstrate to port terminal operators that fuel cell-powered, zero-emissions yard trucks are a safe, reliable, and operationally optimal solution to meet the port's clean air action plan. The project team, led by GTI Energy, accomplished these goals by successfully developing and deploying two fuel cell yard trucks at the Port of Los Angeles. This deployment and demonstration project was the first of its kind and has paved the way for similar future technologies in this space. A temporary refueling station was deployed on-site to ensure reliable refueling of the vehicles and to generate experience for proper evaluation of the impacts of the new technologies on port operations. The researchers credit future generations of hydrogen fuel cell-powered yard truck designs by Capacity largely to the information gathered and lessons learned by the technical project team. The team also gained eSimilarly, the experience with the hydrogen station permitting process and fueling operations provided with valuable insight into future technology deployments in off-highway, industrial, and cargo-handling applications. Extensive public outreach was conducted to share the results of this project, including a video, conference presentations, and webinars. The final report can be found here: https://www.gti.energy/demonstrating-safe-and-reliable-performance-of-hydrogen-powered-terminal-tractors-in-zero-emissions-for-california-ports-zecap-project/	
182	52	Bloom Energy Coupled Electrolyzer and Fuel Cell Demonstration	202102181213	Clean Generation	Distributed Generation		Distributed Generation	4/19/2021	12/31/2025	$500,000	$1,500,000	$450,000	$50,000	$0	Active	$0	Bloom Energy - $1,000,000	Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Next phase of future product development	The goal of this project is to demonstrate the coupling of Bloom Energy's new solid oxide electrolyzer cell (SOEC) at an existing Bloom solid oxide fuel cell (SOFC) installation. A 300kW SOEC will utilize grid electricity to generate hydrogen, which will then be blended with natural gas to fuel Bloom SOFCs. Hydrogen blending will take place downstream of the SoCalGas meter, at a manifold that will feed multiple existing SOFC units on the Caltech campus. The tentative blending percentage is 12% hydrogen (Bloom SOFC's can currently accept up to 50% hydrogen blends). The project will include SOEC product development, hydrogen blending design, permitting, and 15 months of operating costs. The demonstration will showcase the potential to decarbonize the natural gas grid and serve as a steppingstone to developing a reversible SOEC/SOFC fuel cell product.	Yes
183	53	Noble Thermodynamic Systems Ultra-Efficient CHP Using a Novel Argon Power Cycle Development	2020031822540	Clean Generation	Distributed Generation		Distributed Generation	8/14/2020	12/31/2025	$500,000	$5,115,494	$475,000	$25,000	$0	Active	$0	DOE - $3,900,306, Project Partners - $1,215,188	Reliability, Operational Efficiency, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to demonstrate the ability of the novel Argon Power Cycle (APC) to provide an 18% increase in efficiency, while eliminating emissions, in an internal combustion engine. The APC was developed by researchers at the University of California (UC), Berkeley. It utilizes a closed-loop internal combustion engine with argon as the working fluid (instead of air), in conjunction with a membrane gas separation unit. The closed-loop nature of the system completely eliminates air pollutants and GHG emissions. The project will take place at UC Berkeley, with work to be completed in two phases: 1) high-fidelity modeling and sub-component development; and 2) full system integration and operation. The team has progressed according to plan, with only a few minor delays due to supply chain issues. In the meantime, the team has completed the development of high-fidelity code simulating the entirety of the technology, integrating carbon capture technology, reciprocating engine power train, and heat transfer mode. Additionally, the team has completed the design of the overall plant and the design and manufacturing of the retrofit kit for the stock diesel engine. Engine performance estimates show engine efficiencies reaching as high as 62% on an engine scale normally delivering no more than 40%. The entirety of the system is under construction and expected to be ready for firing and integration by Q4 2022. The system will be operated for 18 months after commissioning.	
184	54	NREL GKN Metal Hydride Storage Integration with Renewable Energy and Fuel Cells Demonstration	20211206183920	Clean Generation	Integration & Controls		Integration & Controls	1/1/2022	6/30/2025	$400,000	$2,983,229	$250,000	$150,000	$199,856	Active	$0	DOE - $1,722,089, GKN-$861,140	Reliability, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality, Safety	Late Stage (TRL 7-9)	Commercialization	This project will validate and demonstrate the dynamic operation of GKN's HY2MEGA metal hydride hydrogen storage system integrated with NREL's ARIES platform. The H2MEGA will be the largest metal hydride storage system ever built (520 kg H2 / 17.2 megawatt-hour). The project will be constructed at NREL's Flatirons Campus and will leverage the following ARIES resources: 1.25 MW PEM electrolyzer, 1.0 MW PEM fuel cell, 600 kg compressed H2, 6.3 MW controllable grid interface, battery, and renewable power assets. Renewable electricity will be used to produce green hydrogen via electrolysis, which will then be stored in the HY2MEGA system and a compressed storage system. That hydrogen will then be used to generate electricity via the fuel cell. Simulated energy production and consumption via the controllable grid interface will enable the team to validate the HY2MEGA performance in various real-world scenarios. These simulated use cases will include data centers and remote communities. The project will aim to achieve the following goals 1) Validate the storage and delivery performance of the HY2MEGA technology under a variety of charging and discharging conditions; 2) Demonstrate commercial use cases for a megawatt scale power system; 3) Determine the large-scale hydrogen storage efficiency for a materials-based technology; 4) Demonstrate a safe operating system.	Yes
185	55	NREL Grid Forming Inverters for Fuel Cells Research	20211215171616	Clean Generation	Integration & Controls		Integration & Controls	1/1/2022	3/31/2025	$500,000	$1,749,000	$325,000	$175,000	$233,166	Active	$0	DOE -$1,189,000, UCI - $60,000	Reliability, Operational Efficiency, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Early Stage (TRL 1-3)	Share/publish results	The purpose of project is to develop interconnection and interoperability standards for grid forming fuel cell inverters. Grid forming inverters are critical to maintain and regulate voltage and frequency for parts of the grid without traditional rotational assets (which typically perform this function). In the past few years, grid forming inverters have been successfully integrated with battery storage systems. Due to the operational differences between fuel cells and batteries, standards specific to fuel cell integration with grid forming inverters are needed. This project utilizes NREL's cutting edge ARIES research platform, which is capable of integrated systems modeling and testing at scales up to 20MW. The project will be performed in three phases: hardware-in the-loop modeling, interconnection and interoperability requirement evaluation, and testing/validation of the developed standards in the ARIES platform. The project has three technical goals: demonstrating the ability of fuel cell inverters to transition between grid following and grid forming modes, interconnection standards (how fuel cells connect to the grid), and interoperability standards (how fuel cells communicate w/ other assets).	Yes
186	56	UCI Fuel Cell Supported Nanogrid Controls Evaluation	2021082023224	Clean Generation	Integration & Controls		Integration & Controls	10/18/2021	9/30/2024	$436,653	$556,653	$400,000	$36,653	$0	Active	$0	Heila Technologies and Instant On -$120,000	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	TBD	The purpose of this project is to evaluate two microgrid control platforms in the context of a fuel-cell-supported residential microgrid ("nanogrid"). This project leverages the results of an ongoing project to develop and test a nanogrid control strategy designed to achieve zero net energy in a residential setting with a solid oxide fuel cell (SOFC), PV solar, and battery storage. The university of California, Irvine (UCI) will work with two microgrid controls vendors to evaluate and further develop the capabilities of its control platform(s). The microgrid controllers will be installed in UCI's laboratory nanogrid, which includes a 1.5kW SOFC, 5kW of rooftop solar, and a 9.8kWh battery. The control platforms will be tested for their ability to meet the dynamic operating requirements developed in the previously mentioned supporting project. In addition to the technical testing, UCI will evaluate the greenhouse gas and criteria pollutant emissions implications of the control strategies and determine the cost and equity implications of the test scenarios as applied to the residential demands of various California climate zones.	
187	57	UCI Hydrogen Enabled Microgrids for Critical Infrastructure Research	20211027203855	Clean Generation	Integration & Controls		Integration & Controls	11/22/2021	12/31/2024	$362,442	$562,442	$350,000	$12,442	$0	Active	$0	Microsoft - $200,000	Reliability, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to demonstrate that hydrogen-based renewable fuels—in concert with a cheap and renewable power supply on the electric grid—provide the best techno-economic and long-term solution to meet both 100% renewable energy conversion goals and stringent reliability requirements for essential services like data centers and hospitals. This project leverages previous and ongoing Microsoft co-funded data center research. The University of California, Irvine will design and optimize a fully integrated energy system for a data center. System design will account for site loads, electrochemical energy conversion and storage devices (fuel cells, electrolyzers, batteries), renewable generation (on- and off-site), and dynamic integration with infrastructure grids (electric, gas, water). Optimizations and comparisons will be based on technical capabilities, achieved reliability, and cost.	
188	58	UTD High-Efficiency Combi System Integrating PV and Self-Power - Phase 2 (1.20.G.2)	20210820181519	Clean Generation	Integration & Controls		Integration & Controls	7/1/2021	7/31/2023	$95,769	$450,000	$95,769	$0	$0	Active	$0	UTD Members -$354,231	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions	Mid Stage (TRL 4-6)	TBD	The goal of this project is to develop and demonstrate a hybrid residential combined HVAC and water heating (combi) system in the laboratory that uses off-the-shelf appliances and novel controls to integrate gas-electric systems with micro combined heat and power (mCHP), energy storage, and renewable energy in order to improve efficiencies, reduce greenhouse gas emissions, reduce operating costs, and increase resilience. GTI has successfully operated the nanogrid to achieve self-powered hybrid residential HVAC and water heating using the mCHP system and thermal/electric energy storage to power the combi system and air source heat pump (ASHP). The nanogrid controller manages the various power sources including mCHP, grid power, and solar PV. By using thermal heat recovery from the micro-CHP system together with the ASHP and supplemented with the tankless heater as necessary, GTI is targeting annual coefficients of performance greater than 1.0 serving heating loads down to 5,000 BTUs per hour. GTI is now implementing a test plan to determine the performance of various system configurations: grid parallel, islanded, and integrated with simulated solar PV generation.	
189	59	UTD Integrated mCHP System for Multi-family Building - Phase 2 (1.20.J.2)	202102250221	Clean Generation	Integration & Controls		Integration & Controls	7/1/2021	7/31/2023	$139,249	$480,000	$139,248	$0	$0	Active	$0	UTD Members -$340,751	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	TBD	The goal of this project is to leverage the results of Phase 1, which integrated a Lochinvar CHP, distributed air source heat pumps, and thermal storage in an integrated energy system (IES). This project will expand the capabilities of the system to further test and demonstrate the capabilities of the IES in a multifamily setting. The project team will integrate electric vehicle charging, PV integration, and hydrogen blending in a microgrid configuration to demonstrate resiliency and efficiency benefits. The system will be designed and evaluated in both grid-connected and islanded configurations.	
190	59-2	EPRI ORC Waste Heat Recovery Demonstration	SCG15100138	Clean Generation	Distributed Generation		Distributed Generation	12/1/2015	3/31/2024	$121,593	$1,118,332	$121,593	$0	$0	Active	$0	CEC - $996,739	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Potential field demonstration	The goal of this project is to demonstrate the technical and economic feasibility of a cost-effective organic rankine cycle (ORC) package to recover very low-grade waste heat from natural gas industrial processes. The project team will install a commercially available ORC system at a SoCalGas customer site for monitoring and verification. This will represent the state's first application of ORC technology in an industrial setting. When complete, the project will identify key factors dictating project economics, lifecycle costs, and opportunities for improvement and optimization that could lead to further market adoption and better economics.	
191	59-3	GTI Aisin Residential Fuel Cell Laboratory Testing	2020120201322	Clean Generation	Distributed Generation		Distributed Generation	12/14/2020	3/30/2024	$343,702	$343,702	$343,702	$0	$0	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency, Reliability, Affordability	Late Stage (TRL 7-9)	Potential field demonstration	This project aims to evaluate a residential solid oxide fuel cell (SOFC) for commercialization and widespread deployment in California. SoCalGas acquired two 700W SOFC units from Aisin to be assessed by GTI Energy. The units were modified versions of the commercially available systems in Japan. Modifications include tuning for U.S. gas composition and adding an external transformer for electrical connectivity in the lab.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
192	59-4	GTI Energy Kyocera Residential Fuel Cell Laboratory Testing	20220701231627	Clean Generation	Distributed Generation		Distributed Generation	12/19/2022	3/31/2025	$300,000	$330,000	$250,000	$50,000	$66,619	Active	$0	Kyocera - $30,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Late Stage (TRL 7-9)	Potential field demonstration	The ultimate goal of this project is to develop a residential fuel cell for commercialization and widespread deployment in California. To help achieve this, SoCalGas will acquire two 400W SOFC units from Kyocera to be evaluated by GTI Energy. The units will be modified versions of the commercially available systems in Japan. Modifications will include tuning for US gas composition. The team will operate the systems with an external transformer for lab testing. GTI Energy will work with SoCalGas and Kyocera to develop a test plan, which will, at a minimum, assess the following items: power characteristics (I-V data), power capacities and efficiencies of the system at various loads, system endurance, and stack degradation, load following capabilities, system cycling, start-up and shut-down times, emission rates, heat recovery potential, and stand-alone operation.	
193	59-5	GTI Energy Marathon/EC Power mCHP Testing and Demonstration	2018060164	Clean Generation	Distributed Generation		Distributed Generation	7/1/2018	12/31/2024	$100,000	$1,657,006	$100,000	$0	$0	Active	$0	CEC/ MES,/AO Smith - $1,499,406, ECPower - $47,600, Axiom - $10,000	Environmental: Improved Air Quality, Operational Efficiency, Reliability	Late Stage (TRL 7-9)	Commercialization	The objective of this project is to test and demonstrate two micro-combined heat and power (mCHP) systems—a 4.5 kW Marathon and a 25 kW Lochinvar—to certify both systems under the CARB Distributed Generation Certification Program (CARB-DG).	
194	59-6	GTI Energy Mobile Hydrogen Fuel Cell Generation System Demonstration (CEC MORBUGS)	20220404224915	Clean Generation	Distributed Generation		Distributed Generation	12/21/2022	12/31/2024	$300,000	$2,632,074	$300,000	$0	$0	Active	$0	CEC - $1,99,953, EPRI-$332,121	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Late Stage (TRL 7-9)	Commercialization	This project aims to design and build four easily transportable, integrated hydrogen fuel cell backup generators. Each system will consist of a hydrogen fuel cell, hydrogen storage, battery energy storage, power conversion system, customer and grid interconnection resources, energy management, safety, and monitoring systems. The system, built by Renewable Innovations, will self-sufficiently support a minimum of 10 kW, with 35 kW of continuous load for more than 24 hours, with a peak load capacity of 180 kW. The system will be fueled by hydrogen, providing an opportunity to replace high-emitting diesel backup generators with fuel cell systems that have virtually no emissions and little noise.	Yes
195	59-7	GTI Energy Upstart Residential SOFC Lab Evaluation	20200709164722	Clean Generation	Distributed Generation		Distributed Generation	8/17/2020	8/31/2023	$206,481	$206,481	$206,481	$0	$29,785	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Late Stage (TRL 7-9)	Evaluate Nex Gen Product	This project aimed to evaluate the performance of the Upstart Upgen 10 residential solid oxide fuel cell (SOFC) system at GTI Energy's lab. The technology was originally designed to operate on propane, but modified for testing with natural gas. Unlike other SOFC systems, Upstart claims they created the system to achieve fast start and stop times while maintaining cyclic durability. SOFCs can improve customer energy reliability while reducing GHG and pollutant emissions.	
196	59-8	Mainspring Energy Ultra-Low NOx Linear Power Generator Demonstration	2018091843	Clean Generation	Distributed Generation		Distributed Generation	1/1/2021	3/29/2024	$100,000	$3,767,940	$100,149	$0	$0	Active	$0	CEC - $995,659, Mainspring - $2,672,132	Environmental: Improved Air Quality, Operational Efficiency, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	The goal of this project is for Mainspring Energy to demonstrate their linear generator in a real-world setting. The demonstration took place at a Kroger grocery store in Colton, CA, a disadvantaged community. Mainspring's linear generator uses a low-temperature reaction of air and fuel to drive magnets through copper coils to efficiently produce electricity with near-zero NOx emissions.	
197	59-9	QSI Nano-Power Generation System Proof-of-Concept	20190826205436	Clean Generation	Distributed Generation		Distributed Generation	9/9/2019	11/14/2023	$50,000	$50,000	$25,000	$0	$0	Cancelled	$0	N/A	Operational Efficiency,	Early Stage (TRL 1-3)	Product Development	This project aimed to conduct a proof-of-concept test of the QuSwami, Inc (QSI) patented Nano-Power Generation System, running on natural gas. QSI's system utilizes Electricity Emitting Diodes (EEDs), which directly and efficiently generate power from an energy source via gas-phase catalytic reactions. The reactions occur on an EED's nano-surface, where hot electrons are generated. QSI's foundational research shows that direct conversion of chemical energy from gas-phase catalytic reactions can achieve higher fuel efficiency than most existing electricity generation technologies	
198	59-10	UCI Capstone H2 Blending Research	2022113023433	Clean Generation	Distributed Generation		Distributed Generation	12/1/2022	1/31/2024	$100,393	$100,393	$100,393	$0	$0	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Foundational Research (Pre-TRL)	Share/publish results	This project aims to build upon past research to understand better and address the emissions impact of blending H2 into Capstone microturbines. Prior research indicated that 20% blend levels could be achieved in the C-65 and C-200 models without any observed flashback. However, NOx increases were observed, and controllable via system settings up to a limit. Beyond 20% blending has demonstrated the need for additional system modifications to control emissions.	Yes
199	59-11	UCI Effect of Hydrogen Addition into Natural Gas on SCR of NOx Lab Testing	20200915234440	Clean Generation	Distributed Generation		Distributed Generation	10/5/2020	3/31/2024	$300,000	$300,000	$285,000	$15,000	$99,928	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Share/publish results	This project aimed to investigate the impact of hydrogen-blended natural gas on the performance of selective catalytic reduction (SCR) units for removing nitrogen oxides (NOx) from flue gas. SCR of NOx is used in several applications, such as gas-fired utility boilers, process heaters, gas turbines, and stationary engines. Flue gas composition is known to affect catalyst performance. Since hydrogen is a carbon-free fuel, the combustion products differ from those that contain carbon. Introducing a flue gas with a different composition into the SCR unit affects the chemistry occurring on the catalyst and, hence, its performance. The team thought that this might cause a change in the resulting NOx emissions downstream of the SCR unit, which would be released from the stack.	
200	59-12	UTD Capstone C200S Microturbine Laboratory Evaluation (2.18.E)	20200410225957	Clean Generation	Distributed Generation		Distributed Generation	7/1/2018	6/29/2023	$19,800	$185,000	$19,800	$0	$0	Completed	$0	UTD Members -$165,200	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Share/publish results	This project aimed to evaluate and characterize the performance of the newly launched 200 kW Capstone C200S Signature Series microturbine as a pathway for GTI to scale up its FlexCHP technology. GTI's microturbine FlexCHP technology is an industrial steam/hot water solution that has the potential to enable grid-independent operation with high energy efficiency , without the need for costly post-combustion treatment.	
201	59-13	UTD Emerging Rescom Fuel Cells - Laboratory Evaluations (1.20.F)	20210224162442	Clean Generation	Distributed Generation		Distributed Generation	7/1/2020	6/29/2023	$27,789	$190,000	$27,789	$0	$0	Completed	$0	UTD Members -$162,211	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Mid Stage (TRL 4-6)	Share/publish results	This project aimed to evaluate the merits of residential and small-commercial scale fuel cell systems (<50kW), prioritize them based on fitness for the North American market, and conduct lab testing of select designs. GTI Energy assessed sixteen fuel cell configurations, including alkaline, solid oxide, and polymer electrolyte technologies, all identified for residential or commercial combined heat and power applications. The project team evaluated the merits of the systems based on electrical efficiencies, manufacturer reputation, successful field demonstrations, and North American market fit.	
202	59-14	UTD EnviroPower 6kW SmartWatt and BRASH 3kW STRAUM mCHP Boilers - Lab Test (2.19.E)	20200410224621	Clean Generation	Distributed Generation		Distributed Generation	7/1/2019	6/30/2024	$22,588	$190,000	$22,588	$0	$0	Active	$0	UTD Members -$167,412	Operational Efficiency, Reliability,	Mid Stage (TRL 4-6)	Share/publish results	The objective of this project is to evaluate the 6kW EnviroPower and 3kW BRASH STRAUM Micro-CHP (mCHP) self-powered hydronic HVAC boiler systems in the laboratory, and support their development by validating performance and other competitive analysis benchmarking. Evaluation metrics will include power, thermal production, efficiencies, and emissions.	
203	59-15	Blue Frontier Fuel Cell Integrated Air Conditioning System Dynamic Lab Testing	20210930231913	Clean Generation	Integration & Controls		Integration & Controls	10/18/2021	2/29/2024	$250,000	$493,635	$250,000	$0	$0	Active	$0	CEC - $243,635	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to expand the development and testing of the Blue Frontier AC (BF AC) system, which is a liquid desiccant air conditioner that can be paired with a fuel cell CHP to utilize and store "waste" heat to provide space cooling. Phase 1 involved prototype development, static testing, and conducting an extensive analysis of the benefits of the BF AC, which showed significant energy, cost, and emissions savings when paired with a fuel cell CHP system. This phase of the project will expand the scope to include dynamic testing at UC Davis Western Cooling Efficiency Center (WCEC), who has expertise in this type of testing. Testing will evaluate the performance of the BF AC when subjected to dynamic inside and outside conditions (informed by the building types and climate zones modeled in Phase 1) in psychrometric chambers (rooms where environmental conditions can be controlled and simulated)	
204	59-16	Blue Frontier Fuel Cell Powered HVAC Development	20191010175342	Clean Generation	Integration & Controls		Integration & Controls	11/1/2019	2/29/2024	$540,527	$540,527	$540,527	$0	$0	Active	$0	N/A	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to further the development of the Blue Frontier Air Conditioning (BFAC) system and investigate its integration with a fuel cell CHP system. By using an Enhanced Liquid Desiccant Energy Storage technology originally developed by NREL, the BFAC recovers and stores the waste heat from the fuel cell in order to provide on demand cooling.	
205	59-17	UCI Fuel Cells in Data Centers Research	201906241897	Clean Generation	Integration & Controls		Integration & Controls	10/1/2019	12/31/2023	$190,000	$540,000	$190,000	$0	$0	Completed	$0	Microsoft - $350,000	Reliability, Operational Efficiency, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Next phase of future product development	The objective of this project is to explore the real-world feasibility of using Solid Oxide Fuel Cells (SOFCs) integrated with an absorption chiller to provide power and cooling to a data center. The waste heat from the SOFCs is being used to drive the absorption chilling process. The project is being conducted in UCI's laboratory. For the purposes of testing, a standard 42 slot server rack was provided by Microsoft. In order to meet the 12kW power requirements of the server rack, the project team is using eight 1.5kW Solid Power BlueGEN fuel cells. A 5-ton Lithium Bromide (LiBr) absorption chiller from Yazaki was selected for cooling	
206	59-18	UCI Integrated SOFC, Solar, and Storage System in ZNE Residential Nanogrid Design	20190624172734	Clean Generation	Integration & Controls		Integration & Controls	10/1/2019	1/31/2024	$325,000	$325,000	$325,000	$0	$0	Completed	$0	N/A	Reliability, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Share/publish results	The goal of this project was to design and analyze a residential "nanogrid" that integrates a solid oxide fuel cell CHP system, PV solar, and battery storage to achieve Zero Net Energy (ZNE). The project team has evaluated sixteen climate zones for component sizing and considered system configurations for four scenarios: 1) All Electric: PV + Battery; 2) All Electric: PV + SOFC + Battery; 3) Mixed Fuel: PV + Battery; 4) Mixed Fuel: PV + SOFC + Battery.	
207	59-19	UTD Integrated CHP System for Multi-Family Buildings (1.20.J)	20210224162728	Clean Generation	Integration & Controls		Integration & Controls	6/1/2020	8/30/2023	$30,000	$250,000	$30,000	$0	$0	Completed	$0	UTD Members -$220,000	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Share/publish results	This project aimed to evaluate a laboratory microgrid design featuring an EC Power/Lochinvar XGRi25micro combined-heat and power (mCHP) unit within a multi-family context,coupled with best-in-class electric heat pumps (EHPs) responding to heating and cooling demand.	
208	60	GTI Model-Based Control Hospital Deca	2020101532851	Customer End-Use Ap	Commercial Applications		Commercial Applications	12/1/2020	3/31/2024	$161,250	$6,768,954	$147,000	$14,250	$0	Active	$0	CEC - $1,424,704	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report, Technology & Knowledge Transfer Activities	This project will demonstrate an integrated model-based control solution for reducing space heating and hot water loads in order to decarbonize large commercial buildings. The proposed technology will significantly reduce energy use and GHG emissions. GTI will monitor and report real energy savings and GHG reductions from the installation of advanced technologies at the Baldwin Park Medical Center. The goals of the project are to demonstrate an overall 30% reduction in natural gas usage and a simple payback of less than 3 years, advance the technologies integrated with model-based optimal control from TRL7 to TRL9, and showcase the retrofit measures and energy savings through outreach to encourage similar implementation of energy saving measures throughout the state. In 2021, the project team held their first technical advisory committee meeting on 7/2021 to share their project progress. During their meeting, they shared their analysis on the site characterization including technical information on the boiler and chiller systems used by the medical center. They also discussed their baseline monitoring plan which was submitted on 3/2021 and next steps in the project which include addressing outstanding metering issues, fine tuning energy models, and drafting the final hospital baseline energy usage and modeling report. .	
209	61	UTD CleanO2 CARBiNX Carbon Capture (1.21.C)	20210822222945	Customer End-Use Ap	Commercial Applications		Commercial Applications	7/1/2021	5/31/2024	$30,000	$150,000	$30,000	$0	$0	Active	$0	UTD - $120,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will evaluate the performance of a CleanO2 CARBiN-X v 4.0 carbon capture device in a laboratory setting in order to validate claims of a carbon dioxide capture rate of 4 metric tons per year and cost savings of at least 30% for hot water heating. It will furtherand identify areas for continued technical improvement. Besides the CARBiN-X v 4.0, CleanO2 is working on more advanced prototypes that look to further disrupt the distributed carbon capture market. Depending on the progress in the development of these prototypes, GTI may perform preliminary regulatory and technical analyses to support advancement of this technology. Implementing distributed carbon capture technology such as the CARBiN-X will help reduce greenhouse gas emissions in the residential and light commercial and industrial spaces while retaining natural gas in Zero Net Energy Buildings. .	

	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
210	62	UTD Commercial Heat Pump Water Heater Field Performance Comparison (1.21.F)	20210822223940	Customer End-Use Ap	Commercial Applications		Commercial Applications	7/1/2021	6/30/2025	$4,707	$916,000	$4,707	$0	$0	Active	$0	UTD Members - $161,293 PERC - $30,000 DOE - $720,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	In this project, a comparison between commercial gas and electric heat pump water heater technology will be conducted in one or two field locations as well as in GTI's laboratory using ASHRAE standards to establish the cost and energy saving capability of each technology. The goals are to assess the performance of of these technologies under various conditions, , and to provide equitable comparative information between commercial heat pump technologies. The project agreements were finalized in 2021, and work is expected to begin in early 2022. .	
211	63	UTD Gas Engine Heat Pump Modeling, Testing, and Implementation (1.21.E)	20210822222354	Customer End-Use Ap	Commercial Applications		Commercial Applications	7/1/2021	1/31/2025	$7,631	$320,000	$7,631	$0	$0	Active	$0	UTD Members - $312,369	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will validate natural gas engine-driven heat pump (GEHP) performance for variable refrigerant flow (VRF) systems across a range of conditions. It will expand the market through enhanced energy models using measured performance data, validation of a new method of testing (ANSI/CGA) for new GEHP performance metrics, a technoeconomic assessment to determine the best use of three new GEHP equipment options. These options includeAHU integration kits, Yanmar Hydrobox, and Aisin Hi-Power. The project agreements were finalized in 2021, and work is expected to begin in early 2022. .	
212	64	UTD Gas-Fired Binary Fluid Ejector Heat Pump Water Heater (1.20.E)	2021022503444	Customer End-Use Ap	Commercial Applications		Commercial Applications	7/1/2020	5/31/2024	$19,125	$2,080,000	$19,125	$0	$0	Active	$0	UTD Members - $160,875 DOE - $1,900,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project models, designs, and builds prototypes of a gas-fired ejector heat pump water heater (GFEHP). This first-of-a-kind heat pump uses a novel cycle that combines a binary-fluid ejector and sorption subsystem into one high efficiency cycle. The technology integrates several components that are thermally and hydraulically coupled. The overall objective is to develop and demonstrate GFEHP technology at 12,000 Btu/hr (3.5 kW) capacity in the laboratory and to achieve a COP of 2.0. This will make it twice as efficient as the current state-of-the-art technology on a primary energy basis. This will help retain a high-efficiency role for natural gas for more than 80 million residential users of gas fired water heaters in the U.S. alone. The research team is finalizing the burner design and will begin designing and developing the heat-exchanger system between the flue gas and the working fluid. .	
213	65	UTD Hydrogen-Blended Gas in ResCom Combustion Equipment - Phase 2 (1.20.H.2)	20210822222121	Customer End-Use Ap	Commercial Applications		Commercial Applications	7/1/2021	3/29/2024	$4,350	$150,000	$4,350	$0	$0	Active	$0	UTD Members - $145,650	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will support the potential deployment of up to 30% hydrogen blended gas in North America in commercial and residential buildings, by assessing operational performance, emissions, and safety impacts on at least five standard appliances in a laboratory setting. Specific goals of Phase 2 are to determine the impact of hydrogen blends on efficiency rating and seasonal performance on appliances, to project greenhouse gas (GHG) reduction potential of hydrogen blending at various levels for U.S and Canadian blocking stocks, and to identify safety, emissions, and efficiency benefits or concerns. .	
214	66	UTD Ionic Liquid Absorption Heat Pump for Commercial Water Heating (1.21.I)	2021091522323	Customer End-Use Ap	Commercial Applications		Commercial Applications	12/31/2021	6/30/2024	$2,400	$225,000	$2,400	$0	$0	Active	$0	UTD Members - $222,600	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	The objective of this project is to design and demonstrate in a lab environment an "alpha" working prototype of a low-cost, ultra-high efficiency gas-fired commercial heat pump water heater with a novel semi-open absorption cycle (SOA-GHPWH) that uses a benign ionic liquid, and which provides integrated latent cooling to further maximize efficiency. The target efficiency is COPgas,HW ▯1.60 if only providing hot water, or COPtotal ▯1.80 if also providing indoor cooling and dehumidification. The prototype will be performance-tested at loads (steady and dynamic) typical of commercial buildings with 100 gallons storage and nominal heating output of 145 kBtu/hr. The system uses a simple plastic pump, and most materials of construction are polymers. .	
215	68	UTD Sequestering Non-Condensable Gases for Enhanced GHP Reliability - Phase 2 (1.19.E.2)	20210822221232	Customer End-Use Ap	Commercial Applications		Commercial Applications	7/1/2021	6/30/2024	$2,364	$240,000	$2,364	$0	$0	Active	$0	UTD Members - $197,636 SMTI, Robur - $40,000	Operational Efficiency, Safety, Reliability, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	To successfully advance the use of high-efficiency gas absorption heat pumps (GAHP), it is important to minimize the impact of non-condensable gases on long-duration performance and reliability. The goal of this project is to design and develop non-condensable gas isolation (NCGI) modules and provide research and development support to employ novel, low-cost aluminum heat exchangers to increase long-term system efficiency and reliability and safe operation and reduce the cost of any absorption-type heat pump. The project team plans on demonstrating the performance of the technology in a prototype GAHP. In 2020 through 2021, the project team initiated and completed rounds of corrosion testing with the alloy samples. In parallel, university researchers are initiating atmospheric pressure testing. .	
216	69	UTD Thermoelectric Generator for Self-Powered Water Heater - Phase 4 (1.17.B.4)	20210822215444	Customer End-Use Ap	Commercial Applications		Commercial Applications	7/1/2021	6/28/2024	$6,000	$1,280,000	$6,000	$0	$0	Active	$0	UTD Members - $234,000 DOE - $1,000,000 AO Smith, Sheetak, Marlow - $40,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	The objective of this project is to develop a self-powered, gas-fired tankless water heater to save rate-payers money and energy while enhancing resiliency. In Phase 4, the team will design, build, and test a working alpha prototype. Phase 4 will build upon the hardware testing performed in prior phases to develop the critical components and integrate the design to power a condensing tankless water heater. GTI plans to utilize UTD's Phase 4 funding as cost share to leverage a next round of funding from DOE towards implementing this technology. Phase 4 will also leverage GTI's efforts and relationship with DOE BTO on a related current DOE BTO project, as well as past UTD projects. .	
217	70	UCI Hydrogen Blend Commercial Stove	20210820204140	Customer End-Use Ap	Commercial Food Service		Commercial Food Service	11/1/2021	1/31/2024	$305,000	$305,000	$200,000	$105,000	$0	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability	Mid Stage (TRL 4-6)	Final Report, PowerPoint, Peer-Reviewed Article, Press Release, Webinar	Currently, NOx emissions from cookstoves are not subject to regulation, but they are a strategic end-use device to be considered for future building emissions reduction. While studies suggest a modest decrease in NOx when low amount of hydrogen is added to natural gas in typical stove burners, the levels still approach 80-90 ppm. Reduction in NOx emissions can be achieved by i) reducing the combustion temperature, ii) decreasing the flue gas residence time in the high temperature zone and iii) reducing the excess O2 in the fuel/oxidizer mixture. Catalytic combustion provides the advantage of lowering the temperature of the oxidation reaction, thus resulting in significantly lower NOx emissions. Catalytic combustion of hydrogen and natural gas has been studied in literature separately for various applications. However, there is no study on the evaluation of fuel blends, resulting NOx emissions, and application for commercial cooking. Therefore, in the proposed work, an ultra-low NOx catalytic burner will be designed and built to burn natural gas/hydrogen blends (up to 50%) for commercial cooking applications. This work will be the phase I of a two-phase study. After burner development, phase II will include development of a commercial prototype and involve a commercialization partner to help with the commercialization process. Since the research agreement was executed in late Q4 of 2021, there are no project updates to report. .	
218	71	UTD Gas Fired Warewasher Door Machi	20210822224724	Customer End-Use Ap	Commercial Food Service		Commercial Food Service	7/1/2021	7/31/2024	$19,938	$145,000	$8,938	$0	$0	Active	$0	UTD Members - $125,062	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	UTD Final Report	The objective of this project was to develop gas-fired prototypes of two types of warewashers (dishwashers): the doortype (low-volume) and the conveyor-type (high-volume). These represent a combined 43% segment of the warewasher market. Presently, most commercial warewashers are electric driven, and many electric warewashers use chemicals rather than high temperatures to disinfect, which further increases their environmental impact. Initial estimates indicate a site will only use one-third of the source energy with a gas warewasher compared to alternative technologies. Even a low-usage restaurant, with onl 1,100 therms of annual usage, would reduce the carbon footprint of the restaurant from 49,610 pounds of CO2 per year with electric units to 16,088 pounds of CO2 per year with gas-fired units. In this project, researchers and a manufacturing partner modified current electric-driven warewashers. Different heat exchanger designs were modeled to determine the best-performing designs that fit into the needed footprint of an existing electric warewasher. Prototype heat exchanger(s) were fabricated and put into a prototype along with a burner and blower. A functional prototype was tested for combustion efficiency, safety, and emission standards. Researchers modeled 13 variations of different heat-exchanger designs and tested the combustion system in the laboratory with the prototype tank and heat exchanger. Custom controls were used to tune everything, and excellent results (under 10ppm NOx) were achieved. Technicians assembled the burner, blower, and gas valve assembly, along with a new control for the combustion system. Initial testing of the combustion system in the prototype heat exchanger was completed. .	
219	72	UTD High Efficiency Smart Convection Oven - Phase 2 (1.19.A.2)	2021082222442	Customer End-Use Ap	Commercial Food Service		Commercial Food Service	7/1/2021	6/30/2024	$49,111	$215,000	$49,111	$0	$0	Active	$0	UTD Members - $120,889 Blodgett - $45,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	In this project, researchers are incorporating a heat exchanger to recover heat from the flue and feed it back into the combustion air. The objective is to develop a prototype high efficiency smart convection oven that increases efficiency by at least 5%, and also integrates superior smart operating controls to maximize food preparation quality and consistency. Earlier, researchers investigated a high-efficiency oven design, showing that this design in bench-scale tests was able to achieve a 3% improvement to cooking efficiency and a 10% improvement to preheat energy use despite not being fully optimized. Based on these results and areas for improvement that were found in that initial design, the project team anticipates that a 5%-10% cooking efficiency should be achievable once the design has been optimized. In addition, a targeted 10%-20% reduction in NOx and CO emissions are expected. In 2021, the project team completed basic testing on the modified heat exchanger. Pre-mix testing will follow. The proposed design is targeted to be 10% more efficient than current ENERGY STAR designs. When compared to installed ovens, it could save more than 50% of the energy use (i.e., over 400 therms per year). A 50% savings translates to $300 in savings annually for the customer (assuming $0.75 per therm) compared to baseline existing ovens. It would be expected to pay back in one to two years, since the cost premium may only be around $300-$400. Discussions with a leading manufacturer continue regarding commercialization opportunities and other next steps to make this more efficient oven available to end users.	
220	73	GTI Booster Ejector Enhancement of Co	2020101525135	Customer End-Use Ap	Industrial Process Heat		Industrial Process Heat	12/1/2020	3/31/2024	$110,000	$1,731,556	$45,000	$65,000	$0	Active	$0	CEC - $1,621,556	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	GTI Final Report, CEC Final Report, Press Release, Webinars, Journal Publication (ASHRAE, ASME, and food processing journals)	In this CEC funded project (EPC-19-023), the project team is developing a Booster Ejector Enhancement of Compressor Refrigeration (BEECR) for field demonstration. The proposed solution recovers steam from a gas-fired cooker, extracts the waste heat and water, and sends the waste steam through the ejector which then drives the chiller displacing the consumption of electricity from the refrigeration cycle. Natural gas and water will be saved through utilization of the waste steam for facility needs and providing pre-heating/boiler infeed water heating. The project seeks to achieve at least a 20% reduction in energy consumption in addition to water savings and significant reductions in nitrogen oxides, particulate matter, and greenhouse gas emissions through energy savings. In October 2021, the project team submitted a draft report to the California Energy Commission pertaining to system design, baseline testing, and a field test plan. By the end of 2021, the project team had made progress towards completion of system installation and package monitoring. The project team of GTI, Wilson Engineering Technologies (WET), and Tetra Tech is currently finalizing the measurement and verification plan and the piping and instrumentation diagrams. GTI and WET are coordinating with the chiller and compressor manufacturers—Multistack and Danfoss—to finalize overall system design, including the booster ejector system and heat recovery unit to be installed on the boiler exhaust. Tetra Tech is planning to install a fuel flow meter on the boiler to measure the boiler load profile, which will inform the design of the heat recovery unit, and a buffer tank for thermal energy storage.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
221	74	GTI Waste Heat Effective Transfer in Bre	2020101535820	Customer End-Use Ap	Industrial Process Heat		Industrial Process Heat	12/1/2020	3/29/2024	$177,821	$1,948,387	$136,214	$41,607	$53,205	Active	$0	CEC - $1,410,566 Tower and Campus Brewing - $100,000 UTD Members - $270,000	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Improved Affordability	Late Stage (TRL 7-9)	CEC Final Report, Technology & Knowledge Transfer Activities, Commercialization Plan	In this CEC sponsored field demonstration (PIR-19-004), a Waste Heat Effective Transfer (WHET) technology will be installed in the flue of two micro-distilleries. The WHET recovers waste heat from the brew kettle to provide preheated plant water in the facility hot water tank which will result in significant reduction in natural gas consumption and emission. The WHET is unique because it utilizes a low-cost heat exchange module made of modified tubing that provides excellent heat transfer in minimum space and minimum pressure drop. The tubing surface features disrupt boundary layers which increases gas mixing, resulting in increased average gas temperature, and higher overall heat transfer rates as compared to its competitors. The objectives of this project are demonstrate a cost-effective, modular, and unintrusive waste heat recovery solution that can be installed in a variety of industrial applications and achieve a 15 to 25% recovery of heat from the brew kettle which would result in natural gas savings and the lowering of emissions (carbon dioxide and NOX).	
222	75	UCI Solid Oxide Electrolysis Cells for Gre	202012142447	Customer End-Use Ap	Industrial Process Heat		Industrial Process Heat	3/1/2021	3/1/2024	$550,000	$5,699,861	$550,000	$0	$183,418	Active	$0	DOE - $4,043,993 UCI, Politecnico di Milano, FuelCell Energy, Inc., LEAP - $1,105,868	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Mid Stage (TRL 4-6)	DOE Final Report, Technoloy Transfer Plan, Production Readiness Plan, Journal Publications, Conference Presentation, DOE Webinar/Press Release	The objective of this project is to study, demonstrate, and optimize an integrated, zero-emission prototype for the direct reduction of iron with H_2 produced from a SOEC system. The project is a close collaboration of academia (University of California, Irvine and Politecnico di Milano), industry (FuelCell Energy, Inc.) and a technology transfer company (LEAP). In 2021, the team determined the specific primary energy consumption < 8 GJ/ton DRI for the best performing Hydrogen Direct Reduction configuration at nominal load. Three system configurations have been proposed representing incrementally integrated layouts between the SOEC unit and the shaft furnace. Additionally, the team completed a SOEC model validation on voltage-current curves with an average prediction error <5% on the steam electrolysis experimental measurements. The model predicted electric-to-hydrogen production efficiency of < 35 kWh/kg (or >95% with 120 MJ/kg of H_2 Lower Heating Value) at nominal design steady-state conditions. The project team plans to complete validation of SOEC co-electrolysis model for Hybrid HDR scenario with literature data, begin pressurized stack testing at FCE's manufacturing site, optimize system layouts for steam electrolysis scenarios, and initialize system configurations for co-electrolysis (hybrid HDR) in 2022.	
223	77	UTD High Hydrogen Burner for Commercial and Industrial Applications (2.21.A)	2021082223515	Customer End-Use Ap	Industrial Process Heat		Industrial Process Heat	7/1/2021	1/31/2024	$84,000	$340,000	$84,000	$0	$0	Active	$0	UTD Members - $216,000 ORNL, CalSteel, Gopher Resources, ANL - $40,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will design, fabricate, and test an advanced fuel-flexible hydrogen/renewable natural gas (H_2/RNG) 0.5 to 1 MMBH burner in a commercial scale furnace at GTI's laboratory. The team will partner with two leading large industrial end-users and two national laboratories to ensure that the final prototype burner meets the requirements of the representative end users. GTI has successfully developed and bench-scale tested a 3D-printed burner design at 0.05 MMBH scale capable of operating efficiently and robustly with hydrogen up to 40% H_2. The funding will demonstrate a scaled-up burner with higher hydrogen (up to 60%) to evaluate and commercialize the technology with California Steel, Inc. (CSI), Gopher Resources, Inc., Oak Ridge National Laboratory (ORNL) and Argonne National Laboratory (ANL). Actual field testing of the prototype will be separately funded/authorized. The project agreements were finalized in 2021, and work is expected to begin in early 2022.	
224	79	Lantec Development of Ultra Low NOx F	2019041616262	Customer End-Use Ap	Residential Appliances		Residential Appliances	5/1/2019	12/31/2023	$92,500	$432,500	$70,383	$22,117	$26,855	Retired	$0	SCAQMD - $340,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Mid Stage (TRL 4-6)	SCAQMD Final Report, Certified Low NOX Furnace	The goal of this project is to achieve the design, development, performance and operational testing, certification, and commercialization of residential condensing and non-condensing forced air furnaces utilizing MicroNOx ultra-low NOx combustion technology emitting no more than 7 ng/J NOx. This project will take a novel burner technology "MicroNOxTM", developed by Lantec Products from its current early product development stage along the product readiness levels to a point where the manufacturing partner has a viable product to begin introduction into a commercialized product line. The project team will test the prototype units in accordance with the certification test procedure contained in AQMD Rule 1111 including AQMD Method 100.1. The prototype furnaces will also be tested against ANSI Z21.47 including 10,000 combustion cycles as prescribed within the standard. In 2021, the project schedule was delayed by COVID-19. Despite this, Lantec focused on finalizing the condensing and non-condensing prototype design and completion of non-condensing retrofit furnace. The project team anticipates delivery of the furnaces to GTI for operational testing based on ANSI Z21.47 standards by March 2022.	
225	80	ORNL Residential Hydrogen Blended Sp	20210831175330	Customer End-Use Ap	Residential Appliances		Residential Appliances	11/1/2021	9/30/2024	$600,000	$600,000	$225,000	$375,000	$0	Retired	$ 207,750	N/A	Safety, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordability	Mid Stage (TRL 4-6)	Final Report, Journal Article, Press Release, Webinar, Techno-Economic-Environmental report, Commercialization Plan, IP/Patent	In this project, a residential space heater will be retrofitted with a flameless heterogeneous burner technology to develop a clean and safe space heating appliance capable of operating on hydrogen and natural gas fuels; emissions, safety, turn-down, reliability, and efficiency will be addressed in designing the space heater. When hydrogen is introduced to the fuel mixture, special attention to flame velocity and temperature must be considered. Conventional burners lead to high NOx emissions due to the extreme flame temperature and high flame velocity makes it susceptible to flashback, thus creating safety hazards. Both factors can inhibit usage of hydrogen blended fuel in building heating equipment. Therefore, a low temperature, flameless, heterogeneous catalytic oxidation burner is ideal for safely converting the fuel energy into the desired heat quality. The primary focus of the proposed effort is to enable higher hydrogen blended fuels in a 40k Btu/h space heating system which would accommodate the typical 2000 sq ft home. The objectives of the project are to design, fabricate, evaluate, and optimize a burner capable of operating on natural gas containing up to 40% hydrogen, conduct a techno-economic-environmental analysis to support the business case, study the compatibility of the developed burner with different commercial systems with regards to form and fit with the goal of designing a universal retrofit kit, and identify and engage with an OEM towards a commercialization pathway.	
226	82	UTD Mitigating Methane Emissions from ResCom End Use Equipment - Phase 3 (1.18.F.3)	2021082222623	Customer End-Use Ap	Commercial Applications		Commercial Applications	8/1/2021	12/31/2024	$19,000	$150,000	$19,000	$0	$0	Active	$0	UTD Members - $131,000	Safety, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will quantify methane emissions from at least six key residential appliances that have not been quantified in past phases of the project, in order to develop and publish representative methane emission factors and to determine the conditions under which these appliances release unburned methane and identify potential mitigation options. At least six residential appliances, including cooking ranges and tank water heaters, will be tested under specific operating conditions and representative use patterns, including both steady-state, standby, and cyclic operation.	
227	82-2	METRON Energy Virtual Assistant (EVA)	20200805223421	Customer End-Use Applications	Advanced Innovation		Advanced Innovation	8/31/2020	12/31/2024	$601,069	$601,069	$334,860	$266,209	$67,031	Active	$0	$0	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Final Report	This project will demonstrate METRON's "Energy Virtual Assistant (EVA) Factory Solution", which optimizes industrial processes utilizing machine learning. All types of data from industrial equipment (boilers, chillers, compressed air, dryers, etc.) are captured and processed by the METRON-EVA platform. The platform allows for "non-intuitive optimization," real-time access to data, and easy reporting. METRON hopes to achieve a payback period of fewer than 12 months, and up to 15% total energy savings (electric and gas combined). The goal is to test and demonstrate the technology at up to three (3) locations. Depending on the site, commissioning can be achieved with minimal hardware installation or remotely (if the customer already has monitoring equipment). Frontier Energy will provide independent, third party measurement & verification of the savings. In 2021, the project team interviewed several potential host sites and selected a manufacturer of high-performance composite materials and products for the aerospace and transportation industry. The team decided to focus on one pilot site to guarantee a successful demonstration rather than three. During the site analysis, the project team identified several pathways for significant energy savings including modifications to parameters that affected the electricity, steam generation, vacuum pump, compressed air, expansion, and incinerator processes. In 2022 the team worked on the instrumentation and connectivity of the steam generation and incinerator processes. The energy optimization software has been installed at the host site. The plant managers are familiarizing themselves with the energy dashboard which has high-level control over the plant's operation. The team is working to bring online more variables in the system.	
228	82-3	UTD Gas Fired High Efficiency Liquid De	20190204235233	Customer End-Use Applications	Advanced Innovation		Advanced Innovation	6/1/2018	3/31/2024	$4,000	$415,000	$4,000	$0	$0	Active	$0	UTD Members, NYSERDA - $411,000	Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The goal of this project is to develop a gas-fired liquid desiccant dedicated outdoor air system (LDDOAS) that addresses many of the critical issues facing the HVAC industry. During this project, a research team is collaborating with a manufacturer to compare the current state-of-the-art LDDOAS technology with other advanced systems. The team designed and experimentally evaluated a breadboard LDDOAS test rig rated at approximately 100 CFM using a novel, non-corrosive, non-toxic desiccant. In Phase 1, the project team constructed an experimental gas-fired liquid-desiccant air-conditioning system. In Phase 2, the team upgraded a one-tower test rig and completed liquid desiccant distribution tests. Progress was made on continuous regeneration tests, demonstrating efficiency as high as 70% while sufficiently regenerating the desiccant. In 2021, the project team conducted rigorous testing of dew point sensors and determined that an energy imbalance detected in earlier testing was not due to instrument accuracy. The project team discovered that insufficient mixing of water vapor in the air at the exit of the tower was causing the imbalance. To make certain proper mixing of the air as it exits the tower, the project team constructed a reducer for the top of the tower to increase the flow velocity and turbulence. In 2022, the team completed plans for building a second packed bed column tower to allow for simultaneous regeneration and conditioning. Construction of the second tower is currently underway. The group purchased a new digital refractometer to measure the desiccant solution's refractive index. The project team plans to begin benchtop tests of the desiccant on different material surfaces in the next reporting period.	
229	82-4	CSU Hydrogen Blend on a Caterpillar NS	2021060920511	Customer End-Use Applications	Commercial Applications		Commercial Applications	9/1/2021	1/31/2024	$173,066	$203,066	$173,066	$0	$23,085	Active	$0	In-Kind - Caterpillar (engine equipment) - $30,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability	Mid Stage (TRL 4-6)	Final Report	This engine testing research aims to assess the impact of hydrogen blends on the emissions and performance of a rich-burn engine with a non-selective catalytic reduction catalyst (NSCR). The goal is to test how various fuel-to-air ratio control processes can mitigate impacts. Researchers hypothesize that more advanced systems and controls are needed to accommodate blends with hydrogen content to remain in compliance with air quality requirements. Approximately 1,000 - 2,000 engines are in operation in the SoCalGas service territory, used for water pumping, distributed power generation, and pipeline gas compression. This research could help develop a statewide hydrogen injection standard and a better understanding of hydrogen blending in commercial and industrial (C&I) equipment. The study will also benefit disadvantaged communities because most engines are in municipalities, water companies, and farming areas. Successful project completion will allow the C&I team to work with customers to retrofit their engines before they receive hydrogen blends. In 2022, the research team completed the hydrogen blending system setup, and shortly after, they completed the engine testing. The team is now reviewing the data on hydrogen fuel blending and developing appropriate air-fuel-ratio (AFR) control strategies. The team intends to submit a research paper to the Society of Automotive Engineering's 2023 conference, covering emissions, sustainability, and thermal management topics.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
230	82-5	GTI Gas Heat Pump Water Heating and	179214311	Customer End-Use Applications	Commercial Applications		Commercial Applications	4/17/2017	12/31/2024	$226,000	$1,090,294	$226,000	$0	$0	Active	$0	CEC - $864,294	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report	The goal of this project is to pilot a low-cost gas-fired heat pump (GHP) for integrated commercial water heating and air-conditioning (A/C). The project team deployed the technology at two restaurant sites in the Los Angeles basin. The GHP is a direct-fired, single-effect absorption heat pump using an ammonia/water working pair with an operating heating Coefficient of Performance of 1.40-1.90 (fuel HHV basis). In prior laboratory testing and field applications for space heating, it has an estimated Annual Fuel Utilization Efficiency of >140%. The team anticipates having an equipment cost of approximately half that of comparable GHP equipment. To offset A/C energy consumption, the project team modified this GHP to deliver hot water and supplemental A/C, sized to provide 80 kBtu/h of hot water and 2.5 tons of cooling simultaneously, with 4:1 modulation. Stone Mountain Technologies, Inc. (SMTI) designed this GHP, a startup company specializing in gas-fired heat pumps, with technical support from GTI ENERGY and A.O. Smith. After the project, the research team found that energy savings at both sites were 16%-26% for the Integrated GHP System and 52%-53% for the heat pump. The daily net electricity increase for both sites was 7-8 kWh. The energy savings translate to $970- $2,780/year, or $620-$2,530 when including electricity and using mature quantity production estimates of GHP and other standard equipment costs. The simple payback for the Integrated GHP System ranges from 1.1 to 6.4 years (fuel savings basis). Lastly, the climate impact of the technology yielded a net greenhouse gas reduction of about 46-48% using 2018 CA-statewide emission factors. The project is pending a CEC final publication.	
231	82-6	Momentum Gas Heat Pump Demonstra	2020062416115	Customer End-Use Applications	Commercial Applications		Commercial Applications	6/30/2020	12/31/2024	$55,000	$1,201,850	$55,000	$0	$0	Active	$0	SoCalGas Customer Programs, CEC - $1,146,850	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report	The project's goal is to optimally deploy a state-of-the-art natural gas heat pump technology into a hotel. This technology holds the potential to reduce greenhouse gas emissions greatly and air quality impacts to local communities and populations collocated with this facility while demonstrating energy savings of at least 35% in the form of natural gas consumption (target 50%). In this project, SoCalGas is leading an effort to deploy and demonstrate the technical and economic viability of high-efficiency natural gas heat pumps. The pilot is located at the Westin Bonaventure, a 1.5 million square foot hotel in a low-income and disadvantaged community. In 2021, the host site decided they could no longer support the technology demonstration. As a result, the project team spent most of the year developing a turnaround strategy, including identifying alternative sites. With the assistance of the CEC, several meetings were held with the project team to narrow down candidates, including a large university and a major television production facility. In 2022, the project team finalized contracting for an alternative site, and the group expects procurement of the GHP components in 2023.	
232	82-7	UTD High Hydrogen-Content Fuel in Res	2021022503743	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2020	3/31/2024	$18,900	$179,900	$18,900	$0	$0	Active	$0	UTD Members - $161,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability	Mid Stage (TRL 4-6)	N/A	The objective of this project is to adapt and demonstrate solutions to use high-hydrogen blends (>50% hydrogen by volume) and 100% hydrogen in residential and commercial combustion equipment. The aim is to show multiple solutions in a controlled laboratory environment and leverage international developments and technology transfer. The project goals are 1) to build a hydrogen-blend and experimental test station. Then use the test apparatus to evaluate the performance of hydrogen-compatible prototypes, products, and components from an emerging network of global developers; 2) develop a research and development roadmap to identify and address gaps and opportunities with high-hydrogen-compatible stationary combustion equipment; and 3) use the new hydrogen-blend experimental test station to disseminate and demonstrate the technology, including hosting outreach events with a wide range of stakeholders. In 2021, the project team developed a comprehensive review of hydrogen demonstrations in Europe and Asia that included end-users. In 2022, test stands were built and modified for standardized testing of furnaces and water heaters. The project team completed a preliminary literature review on relevant test and certification methods. The research team developed a comprehensive test plan, with testing expected to occur in the first quarter of 2023. As part of the R&D road mapping and outreach efforts under this project, the team prepared a summary paper for the World Gas Conference held in May 2022. Researchers demonstrated that methane emissions decrease with added hydrogen. There are several emerging options for distributed gas quality and hydrogen sensors. The project team is meeting with representatives from several sensor manufacturers.	
233	82-8	UTD Next Generation Infrared Burner -	2021022504326	Customer End-Use Applications	Commercial Applications		Commercial Applications	6/1/2020	2/29/2024	$9,200	$300,000	$9,200	$0	$0	Active	$0	UTD Members, Solaronics, Alantum Corp - $290,800	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The objectives of this project are to design, build, and test prototype high-efficiency, high-performance, low-emission gas-fired infrared burners that use advanced metal foam material to offer end users new high-efficiency products. The project team collaborated with material and burner manufacturers. Using gas-fired infrared (IR) heaters instead of electric-driven IR heaters can significantly reduce both source energy emissions and end users' operating costs. This project aimed to build on earlier developments to advance a gas-fired IR burner for commercial and industrial use. In this project, researchers investigated advanced metal foam IR burners with better material properties. In 2022, the project team performed heat-flux measurements for the different conditions and compared them with the performance of traditional IR burners. Researchers reviewed the data from the host site, which looked promising. The team expects more discussions with the manufacturing partner and the host site and more data gathering.	
234	82-9	GTI SCAQMD HE/Low-NOx EcoZone Bur	20191029201215	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	11/1/2019	3/31/2025	$350,000	$2,202,000	$150,000	$200,000	$0	Active	$0	SCAQMD, Kroger, SoCalGas Energy Efficiency - $1,852,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report	The project objective is to demonstrate at least 25% NOx emission reduction by optimizing the combustion process in a multi-zoned commercial baking oven within a South Coast Air Quality Management District environmental justice area. The team estimates a 10% reduction in carbon dioxide emissions through combustion system optimization. The goal is to install the major components of the demonstration system (such as the innovative high-efficiency low-NOx ribbon burners and flame analyzers along with advanced combustion and flow controls) on a multi-zone baking oven at a major commercial bakery located in La Habra, California. The project team will follow this step by testing and performing data collection over a wide range of operating conditions to illustrate the anticipated energy savings and environmental benefits. The proposed approach provides the means to minimize carbon monoxide, carbon dioxide, and NOx emissions while operating the burners at the most efficient firing rate possible at every moment of the baking process. Due to limitations caused by COVID-19, the team was delayed in completing field engineering and demonstration system installations until mid-2021. Fortunately, the team turned the project around in August of 2021 when they installed the demonstration system (i.e., the modified combo-burners and oven control system). In 2022, the team was able to successfully startup and shakedown the demonstration system. They are now actively collecting data and monitoring the performance of the EcoZone burner.	
235	82-10	UTD CFS Burner Technology Carbon Red	2022062222313	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	8/31/2022	8/31/2024	$10,000	$160,000	$10,000	$0	$0	Active	$0	UTD Members - $150,000	Reliability, Safety, Operational Efficiency, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The objective of this project is to determine the decarbonization potential of typical commercial food service (CFS) appliances when utilities blend up to 30% hydrogen with natural gas. Phase 2 will focus on full appliance testing and cooking performance impacts and build on the testing of standalone burners and controls in Phase 1. GTI, through its contacts at the North American Foodservice Equipment Manufacturers, will work with CFS manufacturers to identify and supply appliances for testing. Some key performance indicators include the production of efficiency and emissions data for various stock CFS appliances. The team will observe hydrogen blends operating between 0-30%. The team will also create initial recommendations for relevant limits on hydrogen for a spectrum of stock CFS appliances. Finally, the project group will assess possible near-term modifications (e.g., controls or burner designs) to increase allowable hydrogen content. In 2021, a laboratory setup was designed and assembled to test CFS burners. The project team tested a fryer pilot burner as part of the shakedown of the test stand and data-acquisition system. During the shakedown, the team identified a need for a different capture hood and a more accurate gas flow meter. The project team addressed both issues, and testing resumed. In 2022, the team completed testing with the fryer pilot burner. The project team is currently testing a tube burner.	
236	82-11	UTD Commercial Foodservice Equipmen	202102250176	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2020	7/31/2024	$9,000	$90,000	$9,000	$0	$0	Active	$0	UTD Members - $81,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	N/A	This project aims to provide end users, utilities, and researchers with the ability to quickly evaluate appliances, whether gas-fired or electric, and understand their performance. Researchers gathered valuable data from a restaurant and commercial cooking field demonstrations to quantify the operating and efficiency benefits of gas-fired commercial food service equipment in real-world situations. The team tested some of the industry's most recent market introductions, including a steam kettle, range, wok, conveyor oven, convection oven, boiler-less steamer, low-oil-volume fryer, and grill. The team-focused activities were in two areas. The first area focused on single-day demonstrations at test kitchens and trade shows, illustrating how well specific equipment performs. The second area focused on long-term demonstrations in restaurants.	
237	82-12	UTD Gas Fired Warewasher - Phase 2 (1	2021022502521	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2020	7/31/2024	$8,529	$175,000	$8,529	$0	$0	Active	$0	UTD Members, Hobart - $166,471	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The project objective was to develop a gas-fired prototype of a conveyor-type warewasher (dishwasher). Door-type (low-volume) and conveyor-type (high-volume) warewashers represent a combined 43% of the market segment of warewashers. Most commercial warewashers are electric, and many use chemicals rather than high temperatures to disinfect, further increasing their environmental impact. Initial estimates indicate that a site will only use one-third of the source energy with a gas warewasher compared to alternative technologies. In this project, researchers and a manufacturing partner modified current electric warewashers, modeling different heat exchanger designs to determine the best-performing configurations that fit into the footprint of an existing electric warewasher. Various prototype heat exchanger(s) were fabricated and put into a prototype unit along with a burner and blower. The team tested a functional prototype for combustion efficiency, safety, and emission standards. Researchers modeled thirteen variations of heat exchanger designs and examined the combustion system in the laboratory with the prototype tank and heat exchanger. The project team used custom controls to tune everything, and the group achieved highly favorable results (under 10ppm NOx). Technicians assembled the burner, blower, and gas valve assembly, along with a new controller for the combustion system. The project group completed the initial testing of the combustion system with the prototype heat exchanger. A follow-on project could be to apply the design to additional models or to prove its performance and reliability in a field test.	
238	82-13	UTD Technical Support to Address Gas F	20220622222546	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	8/31/2022	8/31/2024	$5,000	$100,000	$5,000	$0	$0	Active	$0	UTD Members - $95,000	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	This project aims to provide technical assistance to the commercial food service (CFS) industry to address issues with energy efficiency, environmental impact, decarbonization, cooking performance, and COVID recovery. GTI Energy will continue to represent the gas industry as a part of technical advisory committees, including the NAFEM Technical Advisory committee, ASHRAE CFS Ventilation, Blue Flame Alliance Technical Advisory Committee, and input to SCAQMD CFS low NOx regulations. The project team will also work with CFS manufacturers and end users to provide data and education on the benefits of efficient gas appliances. Some topics GTI Energy will address and participate in include decarbonization through hydrogen blending, energy efficiency, emissions, and ventilation requirements.	
239	82-14	GTI Energy Burner Exchange to Support	20200824212953	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	9/1/2020	12/31/2024	$74,999	$1,694,999	$0	$139,999	$0	Active	$0	CEC, UTD Members - $1,620,000	Operational Efficiency, E	Late Stage (TRL 7-9)	CEC Final Report	The project aims to demonstrate natural gas savings and emission reductions utilizing an advanced radiative recuperator with secondary emitters (RRSE). For this CEC-funded project (PIR-15-006), GTI Energy and the host site, California Die Casting (CDC), modified a furnace to melt aluminum for die casting with an improved RRSE. The RRSE is more efficient and cost-effective than commercially available recuperators, which primarily recover heat from the exhaust gas and preheat combustion air. The project team will couple the RRSE with commercial hot air, ultra-low NOx burners (Bloom 1500S060C) operated with air preheated to as high as 1200ºF. This approach forms a combined heat recovery system that is highly efficient with low NOx. In addition, a stack to preheat scrap on its way to the furnace with exhaust gas leaves the RRSE to increase furnace efficiency further, lowering natural gas demand. The simple payback for this technology is 30 months. The team completed this project but cannot publish the final results until the CEC's final approval.	

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1	**No.**	**Project Title**	**Project Number**	**Program**	**Sub-program**	**2022 approved new sub-program**	**Research Area**	**Start Date**	**Anticipated End Date**	**SCG Budget**	**Total Project Cost**	**Amount Already Spent**	**Amount Still to be Spent**	**2023 Actuals (1/1-11/30/2023)**	**Status**	**2023 Estimated (1/1-11/30/2023)**	**Co-funders & Co-funding contribution**	**Project Benefits**	**Technology Readiness Level**	**Anticipated Next Steps at End of Project**	**Project Description**	**Hydrogen Blending Projects**
240	82-15	GTI Energy Hydrogen Commercial and I	20220603205711	Customer End-Use Applications	Commercial Applications		Commercial Applications	9/1/2022	9/1/2026	$752,500	$3,807,500	$396,572	$355,928	$0	Active	$0	CEC, PG&E, UTD, EPRI, OEM, others, In-Kind – Industry Alliances (equipment, engineering) - $3,055,000	Reliability, Safety, Opera	Foundational Research (Pre-TRL)	CEC Final Report	This project will support the CEC's GFO-21-503 - Examining the Effects of Hydrogen in End-Use Appliances for Large Commercial Buildings and Industrial Applications. The objective is to conduct a technical study of the impacts of utilizing hydrogen, blended with natural gas and 100% hydrogen, in existing appliances and equipment as a decarbonization strategy for large commercial buildings and industrial processes in California. The research aims to identify and resolve key research and technology gaps through techno-economic analysis, laboratory testing and calibrated simulation of representative combustion equipment and materials, air quality modeling, and stakeholder engagement. The focus will be on understanding the cost, performance, and safety implications and the emissions benefits of adopting hydrogen in these sectors. The project team will also identify and address key benefits, challenges, and potential solutions for increasing hydrogen use in end-use equipment. GTI Energy is leading this effort with the Electric Power Research Institute (EPRI) and the University of California, Irvine (UCI) to complete this wide-reaching study. The team will establish a methodology to select equipment categories based on the magnitude of the GHG emissions associated with the type and the potential for reduction via hydrogen use. The techno-economic analysis will seek to understand the decarbonization potential of using hydrogen to fuel these equipment categories and other measures (e.g., energy efficiency) to 2035 and 2050. The team will make a comparison against business-as-usual and alternative pathways (e.g., electrification vs. diversified path).	
241	82-16	UTD Gas Quality Sensor Validation Hydr	20210822225841	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	7/1/2021	2/29/2024	$15,000	$85,000	$15,000	$0	$0	Active	$0	UTD Members, CMR Group - $70,000	Environmental: Reduced	Mid Stage (TRL 4-6)	N/A	This project will broaden the Gas Quality Sensor (GQS) capability to measure gas composition, heating value, Wobbe number, and methane number for natural gases blended with hydrogen. Indicators that the team sees suggest that GQS accuracy will improve when they add a hydrogen detector. The team will add a hydrogen detector to the previously developed GQS and conduct calibration tests in the project's third phase. Phase three will provide data allowing the extension of the GQS capabilities beyond natural gases to hydrocarbon fuel gas mixtures containing hydrogen. The team will give the generated data to the licensee CMR Group, and combining it with their data, will help to accelerate GQS deployment with hydrogen detection capability. The team will conduct testing in the GTI Energy Industrial Combustion Laboratory's Optical lab space. The lab has the needed blending station, mixing system, computer, and data acquisition system. When CMR is ready to ship the GQS unit for testing, GTI Energy engineers will acquire needed calibration gases and set up instrumentation and data collection computers. This work will take a small amount of the team's time and needs to be conducted just before testing the GQS unit.	
242	82-17	UTD Next Generation Infrared Burner -	20220622223333	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	8/31/2022	8/31/2024	$21,400	$180,000	$21,400	$0	$0	Active	$0	UTD Members - $158,600	Safety, Operational Effici	Mid Stage (TRL 4-6)	N/A	This project aims to test and optimize the performance of the new gas-fired IR burner that UTD is developing under previous project efforts (2.16.A) in partnership with Solaronics, Inc.- a leading gas-fired IR heater OEM, and a top metal foam material OEM. The goal is to operate on high hydrogen blended natural gas, perform tests on the burner with up to 100% hydrogen, and optimize the design to achieve fast start-up, uniform temperature profile, and ultra-low emissions (i.e., < 5 ppm NOx, < 30 ppm CO). Some key performance indicators include demonstrating stable operation with up to 100% hydrogen, providing comparative analysis in terms of temperature, heat flux, stability, emissions, and turndown capability, and achieving fast start-up, uniform temperature profile, and ultra-low emissions. In 2022, the team performed heat-flux measurements for different conditions and compared them with the performance of traditional IR burners. Researchers reviewed the data from the host site, and these looked promising. The team expects more discussions with the manufacturing partner and the host site, and they will gather additional data.	
243	82-18	UTD Ribbon Burner Performance with H	20220622223615	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	8/31/2022	8/31/2024	$20,000	$175,000	$20,000	$0	$0	Active	$0	UTD Members - $155,000	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	This project aims to evaluate traditional ribbon burners' performance when operating with hydrogen and hydrogen-natural gas blends (i.e., 0-100%). The goal is to prove the technical feasibility and identify optimal design performance and design gaps. Some key performance indicators include heat release-temperature profile-emission data in the range of tested conditions and the correlation between hydrogen content in the fuel and test burner performance. The data and correlations obtained will serve as a basis for developing innovative decarbonization concepts that will integrate green hydrogen production, advanced waste heat, and water recovery combined with VOC mitigation and self-powered control.	
244	82-19	EAC H2 Home Appliance Set Validation	20210928235552	Customer End-Use Applications	Residential Appliances		Residential Appliances	12/1/2021	12/31/2024	$137,394	$137,394	$137,394	$0	$41,493	Retired	$0	$0	Environmental: Reduced	Late Stage (TRL 7-9)	Final Report	The SoCalGas Engineering Analysis Center (EAC) conducted validation testing on a set of appliances for deployment at the [H2] Innovation Experience, the first project of its kind in the U.S. aiming to show how carbon-free gas made from renewable electricity can be used in pure form or as a blend to power clean energy systems of the future. The focus of this work was to perform comprehensive equipment validation at the EAC lab with concentrations of hydrogen blended up to 30%. The research team analyzed safety (i.e., flashback, ignition failure, ignition delay, flame profile), emissions, and energy efficiency, which is useful for estimating energy savings. By leveraging the [H2] Innovation Experience, SoCalGas RD&D can field demonstrate a suite of appliances, including a Rinna RU130iN tankless water heater, LG UPSG3014ST Oven Range, and Valor 1700KP fireplace, at up to 20% hydrogen blend. In 2022, the EAC completed its appliance set testing. The equipment was deployed at the [H2] Innovation Experience, which is available for public tours.	
245	82-20	GTI Advanced High Efficiency, Low Capa	2017083043	Customer End-Use Applications	Residential Appliances		Residential Appliances	10/1/2017	12/31/2024	$150,000	$900,000	$150,000	$0	$0	Retired	$0	CEC - $750,000	Environmental: Reduced	Late Stage (TRL 7-9)	CEC Final Report	The goal of this project is the field demonstration and performance testing of advanced high-efficiency, low-capacity heating, ventilation, and air conditioning (HVAC) systems. The team coupled these systems with measures to reduce infiltration and improve building envelopes. The project group outfitted five existing single-family homes with these units and envelope improvements. The aim was to achieve more than 30 percent HVAC energy savings compared to a typical Los Angeles Basin home with standard equipment. The project team produced 24 months of data from five homes in Los Angeles and Orange County. The newly installed equipment had a lower capacity than Title 24 compliant or existing systems, 50% or lower than the equipment in the demonstration homes. The results illustrated the benefits of envelope upgrades and right-sizing the HVAC for homes with improved envelopes. The project team leveraged a combination of utility data analysis and a calibrated BEopt model to prove the potential for HVAC energy savings to be greater than 30%. The project team submitted the final report in November 2021, which they will publish as an official CEC publication. A public webinar was held on August 25, 2021, to share the project findings.	
246	82-21	GTI Hydrogen Blend Burner Design Anal	20210609204322	Customer End-Use Applications	Commercial Applications		Commercial Applications	9/1/2021	6/30/2024	$280,000	$280,000	$70,000	$210,000	$0	Active	$0	$0	Environmental: Reduced	Mid Stage (TRL 4-6)	Final Report	In this project, GTI Energy proposes developing numerical models (i.e., computational fluid-dynamic and reduced-order models) that can quickly simulate different burner types and design variations. The project team will validate the models against experimental data and then use them to 1) identify blending limits with existing burner designs; 2) understand the impact of hydrogen blends on flame stability, burner material durability, and emissions; 3) propose mitigation strategies; and 4) develop industry guidelines for burner designs which expand hydrogen blending limits while maintaining compatibility with natural gas. In 2021, GTI Energy completed the initial literature review of reduced-order models and classic burner design methods. Based on the literature review, GTI Energy is developing a computational fluid dynamic (CFD) model to use as a testbed for different CFD methods to test design theories for fuel-flexible burners. GTI Energy has also begun assembling a list of appliances and burners to test. In 2022, GTI Energy prepared a market survey to understand the types and prevalence of legacy appliances still operating in the SoCalGas service territory. E&W, a consultant assisting with the market survey task, has completed the survey and compiled the results into a draft report issued in late November. GTI Energy is currently reviewing the results with E&W. The team received 27 "good" responses from a combination of homeowners, renters, and property managers. Lastly, GTI has completed testing with the first gas dryer burner identified, indicating no issues with hydrogen blends up to 30% at typical operating conditions. The team has also tested a cast iron boiler burner with up to 30% hydrogen, with no stability or emissions problems observed.	
247	82-22	GTI Strategic Pathways and Analytics Fo	2021091323426	Customer End-Use Applications	Residential Appliances		Residential Appliances	10/1/2021	12/31/2024	$125,000	$1,091,358	$118,098	$6,902	$0	Retired	$0	CEC - $966,358	Safety, Improved Afforda	Late Stage (TRL 7-9)	CEC Final Report	This project will develop a multi-disciplinary and objective analytical framework to identify locations in Southern California where decommissioning can occur in a just, equitable, and cost-effective way. California has some of the most ambitious policies in the U.S. for reducing emissions associated with natural gas use. In some areas, decommissioning natural gas and switching customers to electricity may be a cost-effective approach to meeting these goals. Over time, decommissioning practices of the gas system will greatly impact customers and the gas and electric utilities. Ensuring that socioeconomic equity issues are not exacerbated through decommissioning is paramount. The project team includes an impartial California-based think-tank—the RAND Corp—along with SoCalGas, Southern California Edison, GTI Energy, and LA Regional Collaborative (LARC). The team will combine detailed gas system models with data on candidate communities' socioeconomic conditions to evaluate different decommissioning approaches. The team will work directly with Long Beach and Santa Monica stakeholders in a series of workshops to understand the key needs and concerns of the natural gas customers and then evaluate different decommissioning strategies along with cost, viability, and equity lines. Through these workshops, the team will present specific recommendations for three decommissioning pilot projects and write a set of guidelines and criteria to inform decommissioning of natural gas infrastructure in other areas. In 2022, the project team developed a set of decommissioning scenarios with their engineering teams. They are performing detailed engineering analyses to understand the impacts of decommissioning different portions of the system in Santa Monica.	
248	82-23	ORNL Hydrogen Fueled Cooking Equipm	20200725232713	Customer End-Use Applications	Residential Appliances		Residential Appliances	10/1/2020	12/31/2024	$400,000	$930,000	$400,000	$0	$0	Retired	$0	DOE, In-kind - Samsung (equipment) - $530,000	Environmental: Reduced	Mid Stage (TRL 4-6)	Final Report	The objective is to develop clean, reliable, and safe residential cooking appliances equipped with catalytic oxidation burners capable of operating on 100% hydrogen and natural gas blends (up to 50% hydrogen) while producing zero NOx. In this project, the team will retrofit a residential cooking range and oven with flameless radiant burner technology for testing in the lab. This technology has many advantages, such as emissions reduction, wide turndown, safety, and operation with lean mixtures beyond flammability limits. In 2021, the project made progress toward designing and specifying a prototype. The team evaluated preliminary burner designs for different operating scenarios. The team worked with several manufacturers to fabricate the early-stage prototype design, and the project team issued a purchase order at the end of the year. In April 2022, a prototype burner was manufactured and tested with hydrogen and natural gas blends. In June 2022, the team fabricated the finalized design of burners for full system integration on a Samsung residential cooktop. In September 2022, the team installed hydrogen-compatible burners in the cooktop. Comprehensive performance testing on the cooktop using hydrogen and natural gas blends began in September, and the team completed it before the year-end. ORNL will issue a final project report and press release in the second Quarter of 2023.	
249	82-24	UCI Catalytic Burner Retrofitted Water	20200716215134	Customer End-Use Applications	Residential Appliances		Residential Appliances	9/1/2020	12/31/2023	$410,000	$435,000	$114,999	$295,001	$0	Retired	$35,000	In-Kind - AO Smith, Alzeta, American Catalytic (equipment) - $25,000	Environmental: Reduced	Mid Stage (TRL 4-6)	Final Report	This project is a follow-up to a previous project that identified several viable flameless radiant burners that the industry could retrofit to achieve near-zero NOx emissions from commercially available water heaters. While these burners have existed for some time in different applications, they have yet to be installed into water heaters. Thus, for comparison, several burner configurations will be procured and deployed in water heaters. The team will assess the performance of the retrofitted water heaters (I.e., ignition performance, efficiency, emissions, and tolerance to hydrogen content). The study will compare the results to the legacy burner technology commonly found in water heaters. The relative tolerance to hydrogen content will also be evaluated, providing insight into how these burners can help reduce carbon emissions from natural gas with hydrogen blends. In 2021, the University of California, Irvine (UCI) procured and designed one of three burner technologies they plan to develop as a retrofit kit for commercially available water heaters. They completed the first batch of preliminary tests on the first burner design. In 2022, the research team completed their initial performance, emission, and safety evaluation while beginning the design process of integrating the catalytic burner into a full-scale system.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
250	82-25	UTD Boostheat Thermal Compression-B	2021022503118	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2020	6/3/2024	$26,667	$225,000	$26,667	$0	$0	Active	$0	UTD Members, OEMs - $198,333	Environmental: Reduced	Mid Stage (TRL 4-6)	N/A	The objective of this project is to develop a North American thermal heat pump (THP) with a focus on 1) a high modulation ratio, 2) integration with forced-air distribution, and 3) adding cost-effective cooling. Project partner BOOSTHEAT has recently established an innovative and new business model in Europe. To successfully enter the North American market, however, this UTD project will address key product development needs. THPs have significant potential for 20% or greater improvement in energy savings and emissions reductions versus best-in-class conventional sorption and vapor compression-type THPs. The project team completed laboratory preparations for testing the BH.20 using a Virtual Test Home (VTH) protocol. The test infrastructure is complete, and the remainder of the activity focuses on data acquisition and control setup. The test apparatus is undergoing shakedown to test a different heat pump before the arrival of BOOSTHEAT's unit. BOOSTHEAT experienced a production delay in 2020-2021 for various reasons. The company addressed key technical challenges and consolidated staff under a single roof. In early 2022, the company indicated that their new units' reliability and performance had improved. BOOSTHEAT is also re-developing the packaging and controls of the thermal compressor so that the BH.20 can provide both space heating and domestic hot water. BOOSTHEAT expects to make a unit available for testing and additional technical refinement (including using a VTH protocol) in the first quarter of 2023.	
251	82-26	UTD Gas Engine Heat Pump Modeling, T	2022062222053	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/31/2022	8/31/2024	$5,900	$180,000	$5,900	$0	$0	Active	$0	UTD Members - $174,100	Operational Efficiency, In	Mid Stage (TRL 4-6)	N/A	This project aims to demonstrate the recently-introduced Yanmar Air Handling Unit (AHU) Integration Kit at a cooling-demonstration site to validate performance and savings in life cycle costs. The AHU kit pairs a high-efficiency gas engine-driven heat pump (GEHP) to a packaged rooftop air handling unit to apply GEHPs to a broader range of commercial buildings and minimize installation costs. A successful demonstration of the AHU kit will support a high-efficiency and cost-effective role for natural gas in commercial buildings for cooling-dominated climates. Some key performance indicators are to obtain at least 12 months of field data, achieve a seasonal coefficient of performance (COP) > 1 for both cooling and heating performance, and publish results in the technical paper and conference presentation. The project team compared hourly measured field data on the heating and cooling performance with the limited laboratory test data on the same unit. In 2022, the group held regular meetings with the National Research Council Canada staff and Yanmar Co., Ltd. to collaborate on GEHP model development and share performance data.	
252	82-27	UTD Hydrogen Blending End-Use Perfor	20220622221254	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/31/2022	8/31/2024	$16,000	$450,000	$16,000	$0	$0	Active	$0	UTD Members - $434,000	Safety, Operational Effici	Mid Stage (TRL 4-6)	N/A	This project intends to demonstrate blended hydrogen gas's safety, technical, and performance implications from an end-user perspective in a simulated neighborhood. The project aims to 1) measure the end-user performance and safety impacts of a wide array of fuel-fired equipment (e.g., HVAC, water heating, cooking), 2) quantify the efficacy of in-field retrofits and mitigation strategies for individual appliances, and 3) estimate the decarbonization potential of hydrogen blending through population modeling. In coordination with Southwest Gas, the project team seeks to leverage their utility training facility in Henderson, NV, as a hydrogen-blended equipment demonstration and outreach platform. The project will leverage the site's existing plans to install and operate an on-site electrolyzer to blend hydrogen at a variable rate into an islanded distribution network serving the training facility. The 15 homes within the simulated neighborhood will house the experimental equipment.	
253	82-28	UTD Hydrogen-Blended Gas in ResCom	2022062221486	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/1/2022	8/1/2024	$10,000	$150,000	$10,000	$0	$0	Active	$0	UTD Members - $140,000	Safety, Operational Effici	Mid Stage (TRL 4-6)	N/A	This project intends to support the potential deployment of up to 30% hydrogen blended gas in North American buildings. The team will assess the performance, emission, safety, and quality impacts of hydrogen mixing on widely used but low-load peripheral gas appliances such as gas lights, space heaters, outdoor fire pits, and indoor fireplaces. Specifically, the project team aims to determine the impacts and limits of hydrogen blending on these gas systems, assess qualitative results on aesthetic combustion equipment, and recommend changes for improved compatibility and performance. In 2022, test stands were built and modified for standardized testing of furnaces and water heaters. The team completed a preliminary literature review on relevant test and certification methods. The research team developed a comprehensive test plan, with testing expected to occur in the third or fourth quarter of 2022. As part of the R&D road mapping and outreach efforts under this project, the team prepared a summary paper for the World Gas Conference held in May 2022. Researchers demonstrated that methane emissions decrease with added hydrogen. The response to results was very positive, particularly with high interest from organizations in Latin America. There are several emerging options for distributed gas quality and hydrogen sensors. The project team is meeting with representatives from several sensor manufacturers.	
254	82-29	UTD Next Generation Residential Gas Di	202101223436	Customer End-Use Applications	Residential Appliances		Residential Appliances	7/1/2020	7/31/2024	$28,000	$160,000	$28,000	$0	$0	Retired	$0	UTD Members - $132,000	Environmental: Reduced	Mid Stage (TRL 4-6)	N/A	The goal is to find a technology to achieve a 5-15% edge over standard efficiency gas dryers. In this project, researchers are investigating next-generation gas dryer technologies to exceed EnergyStar efficiency levels. They developed an early-stage prototype with promising technology. Phase 1 of this project focused on assembling a test station in an environmental chamber to maintain temperature and humidity to make certain accurate testing. In Phase 2, researchers investigated additional heat-recovery options, modulation techniques, indirect-fired methods, direct venting, and alternative burners. Testing at four firing rates consistently showed around a 2% improvement with lower firing rates. The dryer was insulated and sealed to test potential boost from fewer leaks and allow heat recovery implementation. After several variations, technicians achieved a 5%-6% increase in insulation and sealing efficiency and a 6% reduction in drying time. The insulation and sealing also allowed researchers to implement an innovative heat-recovery design. Any proprietary technologies discovered during the project will result in a UTD invention disclosure. In 2022 under Phase 3, the team built an environmental chamber to perform a subsequent product development and testing round. Researchers are awaiting the completion and availability of a new test chamber to complete testing.	
255	82-30	UTD Residential Gas Absorption Heat Pu	20200401223018	Customer End-Use Applications	Residential Appliances		Residential Appliances	7/1/2019	6/28/2024	$42,491	$170,000	$42,491	$0	$0	Retired	$0	SMTI, UTD Members - $127,509	Environmental: Reduced	Late Stage (TRL 7-9)	N/A	This project builds upon a gas-fired heat pump water heater (GHPWH) developed and supported in conjunction with UTD Project 1.11.H, scaling up the same absorption heat pump technology by an eight-fold factor. The objective of this project is to support the development of next generation GHPWH by eliminating a major cost hurdle for some installations and enhancing reliability and efficiency diagnostics. One effort was to reduce the installation cost/barrier of condensate drain by developing a proprietary method of neutralizing, collecting, and disposing of combustion condensate where access to a sanitary sewer drain is otherwise cost-prohibitive and improving the onboard diagnostics by exploring the use of Enhanced Solution Level Control (ESLC) which can improve system reliability and long-term performance. Using the experience of 12 demonstrations of Phase 1 to 4 GHPWH precommercial prototypes, GTI and SMTI have identified typical conditions and root causes of poor efficiency and/or product failure. In July 2021, it was announced that UTD member Enbridge had invested CAN $4,000,000 in the late-stage start up SMTI, the developer of the technology advanced in this and other UTD projects. The project team is finalizing preparations for installation of GAHP hybrid equipment in the laboratory, with thermal heat pump test station upgrades. Researchers are analyzing the results of testing to make recommendations on system design modifications, sizing considerations, and controls updates.	
256	82-31	UTD Residential Gas Absorption Heat Pu	2021091604315	Customer End-Use Applications	Residential Appliances		Residential Appliances	7/1/2020	8/31/2024	$15,000	$200,000	$15,000	$0	$0	Retired	$0	UTD Members - $185,000	Environmental: Reduced	Mid Stage (TRL 4-6)	N/A	This project was based upon a gas-fired heat pump water heater (GHP-WH) developed and supported in conjunction with UTD Project 1.11.H. This project aims to scale up the same absorption heat pump technology by a factor of eight. The objective is to support the development of the next-generation GHP-WH by eliminating a major cost hurdle for some installations, along with enhancing reliability and efficient diagnostics. One effort is to reduce the installation barrier and cost of a condensate drain by developing a proprietary method of neutralizing, collecting, and disposing of combustion condensate. This aspect benefits users where access to a sanitary sewer drain is otherwise cost-prohibitive. Also, the team can leverage Enhanced Solution Level Control (ESLC) to improve the onboard diagnostics, which can enhance system reliability and long-term performance. Using the experience of 12 pre-commercial GHPWH prototypes tested in demonstrations conducted in Phases 1 to 4, GTI Energy and Stone Mountain Technologies, Inc. (SMTI) identified typical conditions, root causes of poor efficiency, and product failures. SMTI is the developer of the technology advanced in this and other UTD projects. Technical tasks under Phases 5 and 6 improved the final design and fabrication of test setups to evaluate the proof of concept of the liquid level sensor (LLS) platform and the de-condensation idea. For Phase 6, the team completed an agreement with SMTI to produce a next-generation alpha prototype GHPWH. SMTI delivered the updated unit in the fourth quarter of 2022. Researchers concluded the Phase 6 test plans and fabricated prototypes of additional features.	
257	82-32	UTD Safe Use of Hydrogen in Buildings (	20220622221943	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/31/2022	8/31/2024	$10,000	$150,000	$10,000	$0	$0	Active	$0	UTD Members - $140,000	Reliability, Safety, Enviro	Mid Stage (TRL 4-6)	N/A	The purpose of this project is to enable the broad deployment of hydrogen-blended gas by proactively addressing consumer and regulatory concerns about its safe use in buildings. This project will characterize the propensity of hydrogen in blends with natural gas to preferentially leak from existing building gas distribution systems and appliance gas handling subsystems. This project also aims to address barriers to the safe use of higher hydrogen blends greater than 30% in residential and commercial appliances. Some key performance indicators are 1) quantifying leakage of hydrogen blended gas compared to natural gas from standard fittings, 2) identifying design requirements for high hydrogen blend operation (i.e., 40-100%), and 3) publicly disseminating findings and recommendations through peer-reviewed publications and webinars. In 2022, GTI Energy kicked off the project with a literature review into prior research on preferential hydrogen leakage from low-pressure gas distribution systems and fundamentals of detonation wave formation for mixtures of methane and hydrogen. GTI Energy is also working on installing and configuring Converge computational fluid dynamics (CFD) software which will be used to analyze detonation wave formation.	
258	82-33	UCI Low NOx Water Heater Retrofit for	2020072501614	Customer End-Use Applications	Residential Appliances		Residential Appliances	9/30/2020	5/30/2023	$241,468	$273,468	$241,468	$0	$108,674	Completed	$0	Rheem - $32,000	Reliability, Safety, Enviro	Mid Stage (TRL 4-6)	Final Report	The project's objective was to take existing low NOx water heaters and improve the operational limits of hydrogen tolerance. The project's goals were to evaluate the modifications that would allow adding additional hydrogen, to carry out the improvements, and to demonstrate the amount of additional hydrogen that could be blended and allow reliable operation. The team did laboratory testing to evaluate general observations, ignition, flashback, and efficiency. In addition, the team quantified emissions to understand how the NOx, carbon monoxide, and unburned hydrocarbon (UHC) levels change with increased hydrogen addition. In 2021, the team evaluated, baselined, and proposed several modifications to the water heaters they received. Some methods they used to assess the water heaters included thermal imaging of the burner top to understand the temperature distribution, thermocouples to measure the surface temperature, and fuel control to vary the hydrogen-natural gas mixture. In 2022, the team completed the initial testing of their appliance set. The research team focused on design modifications to improve the hydrogen tolerance of the burners and is evaluating those modifications under comprehensive safety, performance, and emissions testing. A journal publication was released on 3/3/2023. https://www.sciencedirect.com/science/article/pii/S036031992300722X.	
259	82-34	UTD Accelerated Life Testing of ResCom	20231018182617	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$150,000	$0	$0	$0.00	Active	$0	UTD Members - $135,000	Safety, Reliability, and Re	Mid Stage (TRL 4-6)	N/A	This project aims to evaluate the performance of non-burner components in residential and commercial combustion devices with hydrogen-blended gas. The results will inform gas stakeholders about the potential issues of using hydrogen in gas networks. The key performance indicators of success are a report that lists the compatibility or degradation of each component when exposed to H2, a set of recommended strategies to address any problems identified by the report, and a publication in a peer-reviewed journal or conference proceedings that details the findings and methods of the project, and the compatibility problems that were or were not found. The project will also produce the following deliverables: component compatibility or degradation reports, problem mitigation strategies, and peer-reviewed publications of findings and methods. The primary target markets impacted by this project are standard gas equipment used in appliances, such as valves, regulators, tubing, etc., and residential, commercial, and industrial combustion equipment designed for natural gas.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
260	82-35	UTD Advanced Controls for Residential	20231018183536	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$200,000	$0	$0	$0	Active	$0	UTD Members & PERC - $190,000	Operational Efficiency, E	Mid Stage (TRL 4-6)	N/A	This project aims to address indoor air quality (IAQ) issues related to residential cooking by developing better ventilation control systems to improve IAQ, save energy, and reduce carbon footprint. The main tasks of the project are as follows. First, evaluate novel advanced controls for demand-controlled kitchen ventilation systems. Second, monitor energy input to cooking appliances and local IAQ. Third, develop appliance control panel logic that can adjust ventilation flowrate and identify issues with the appliance. Fourth, evaluate hood performance during modulation and measure capture efficiency using a shadowgraph system. The key performance indicators to measure the project's success include a 30% improvement in capture effectiveness compared to standard ventilation hoods, a 10% reduction in conditioned air losses compared to standard ventilation hoods, and energy savings through winter and summer heating and cooling loads. The deliverable for this project will be a quick response control system that can automatically modulate the ventilation rate based on the cooking activity and the appliance energy measurement method that can monitor the energy consumption of the cooking appliances.	
261	82-36	UTD CFS Burner Technology Carbon Red	20231018183318	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$150,000	$0	$0	$0	Active	$0	UTD Members - $122,000	Operational Efficiency, E	Mid Stage (TRL 4-6)	N/A	The project aims to determine the potential decarbonization of commercial foodservice (CFS) appliances when using 100% hydrogen or blends of up to 30% hydrogen in natural gas. Phase 3 will focus on full appliance testing and cooking performance impacts and will build on the testing of standalone burners and controls in Phase 1 and appliances in Phase 2. GTI, through its contacts at NAFEM (North American Foodservice Equipment Manufacturers), will work with CFS manufacturers to identify and supply appliances for testing. 100% hydrogen appliances will come from outside North America. Specific tasks to complete include testing a 100% hydrogen fryer from Falcon and a grill from Heatlie, expanding existing appliance blend tests with a to-be-determined manufacturing partner, and determining if cooking with hydrogen or hydrogen blends causes degradation of cooking utensils. Some key performance indicators to measure the success of Phase 3 will include the results of testing the 100% hydrogen fryer and grill, performance data for up to five CFS appliances from these equipment types with hydrogen and hydrogen-enriched natural gas (measuring efficiency and emissions such as O2, CO2, CO, NOx, and evaluating cooking performance and flame appearance) and communicating findings to CFS manufacturers. The deliverables for this project will be data, calculations, and experimental test results that support the decarbonization of CFS appliances using hydrogen blending. The results will show if hydrogen or hydrogen blending harms combustion performance, cooking performance, and safety.	
262	82-37	UTD CFS Decarbonization Tool Developr	20231018183211	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$125,000	$0	$0	$0	Active	$0	UTD Members - $119,643	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The goal of this project is to demonstrate and promote the value of efficient, clean, burning gas-fired cooking equipment and advanced Commercial Foodservice (CFS) equipment to the CFS industry. The project will modify demonstration tools with Hydrogen-blended gas and source-based energy calculations. The project will measure its success by quantifying the benefits of natural gas (NG) and NG/Hydrogen blends in high-efficiency gas-fired CFS appliances, including calculating carbon footprint improvement and energy savings. The modification of Foodservice Energy Monitoring System (FEMS) Software to show the carbon footprint, source efficiency, and source emissions for electric, natural gas, and NG/hydrogen blended CFS appliances. The tool will then be able to provide a source-based total impact of tested appliances as they are cooked live and provide lifecycle cost savings and payback periods for any location across the country. The installation of FEMS capability at one utility test kitchen and the conduct of a live cooking demo with updated FEMS and NG/H2 to show the large carbon reduction capability of high-efficiency gas-burning CFS equipment. The team will compare the performance, food quality, and quantity with electric appliances. The project will provide the following deliverables: updated FEMS Software with source-based energy use, emissions, and carbon impact and expected lifecycle payback for both NG and NG/H2; installation at one utility test kitchen; and a demonstration of software cooking on high-efficiency CFS appliances with both NG and NG/hydrogen as well as electric appliances.	
263	82-38	UTD CleanO2 CarbinX Carbon Capture -	20231018181924	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$ 220,000	$0	$0	$0	Active	$0	UTD Members, CleanO2 - $206,400	Improved Affordability, E	Mid Stage (TRL 4-6)	N/A	The objective is to develop and test CleanO2's next-gen commercial carbon capture unit, CarbinX v. 4, focusing on condensing appliances. The aim is to achieve a carbon capture efficiency of ≥50% and a payback period of ≤5 years. Key Performance Indicators include compatibility with natural gas and propane condensing appliances, the effectiveness of the new cartridge design, and optimal waste heat recovery. The results will be published in a technical paper or conference presentation. Phase 2 of UTD 1.21.C will further validate the importance of distributed carbon capture technology within buildings, guiding the technology developer towards a product that can decarbonize a wider range of water heating appliances, including natural gas and propane-fired boilers. The primary markets for CleanO2's carbon capture technology are residential and commercial buildings, including multifamily homes, assisted living facilities, hotels, schools, offices, shopping malls, and commercial boilers with a capacity between 250 and 1,500 MBH. The technology aligns with UTD's goals to save consumers money and reduce GHG emissions. The current version reduces GHG emissions by 20%, with a target of 50% reduction for the next-gen v.4 unit and eventually 100% for future technology. The payback for the carbon capture unit based on average usage is approximately six years. With CleanO2's next-gen v. 4, rebates could potentially be multiple times that of the current technology iteration, significantly reducing the payback period.	
264	82-39	UTD Combustion Technology for Emerg	20231018182440	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$ 225,000	$0	$0	$0	Active	$0	UTD Members - $189,720	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The objective of this project is to conduct a comprehensive evaluation of equipment that is already designed or being operated with manufactured gases in markets outside North America. The primary focus of this evaluation is on water heating and cooking applications, including performance and reliability tests. The goal is to identify key principles that can be applied to the types of natural gas-certified equipment typically sold in North America. In addition, a safety and technical review of emerging low-carbon manufactured gases used in various applications such as water heating, cooking, and space heating will also be conducted. These manufactured gases can include hydrogen blended with natural gas and emerging methane substitutes or hydrogen carriers such as ammonia, liquid-organic hydrogen carriers (LOHCs), and renewable hydrocarbons like bio-propane and rDME. Several Key Performance Indicators will gauge the success of the project. These include creating a list of appliances using manufactured gas across global markets and identifying the design modifications typically employed in these appliances for them to function with manufactured gases. The project will also involve testing appliances, developing performance data for appliances with hydrogen blended into natural gas, and identifying opportunities for technology and safety transfer to North America. This approach includes six water heaters and six ranges/cooktops. Lastly, a safety and technical review of emerging manufactured gas impacts beyond H2 will be conducted.	
265	82-40	UTD Controlled Mixing Burner for Proce	20231018192236	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$ 305,000	$0	$0	$0	Active	$0	UTD Members - $296,400	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The project's objective is to design, build, and test a laboratory prototype version of an innovative 0.5-1 million Btu/hr process heating burner for natural gas and alternate low-carbon fuels (LCFs). This approach will enable adopters of LCFs in process heating applications to use varying amounts of LCFs in their fuel streams, including up to 100% carbon-free fuels (CFFs) such as H2 and NH3. The project aims to demonstrate through laboratory testing that the flame size and shape, heat release profile, emissions, and turndown capability remain unchanged, irrespective of fuel carbon content. The team will test the prototype under different furnace temperatures, % carbon in the fuel, and other simulated operating conditions to assess the applicability of the technology to key end users as they seek to decarbonize operations. Key Performance Indicators for project success include achieving less than 25% change in flame length, NOx emissions, and peak heat release distance for 0 to 100% H2 or NH3 blended in natural gas. The burner should maintain a 4:1 turndown and less than 50 ppm CO with no stability, ignition, or flame sensing issues. The burner's estimated cost and control complexity should be comparable to conventional burners. The project also aims to obtain an expression of interest from a major burner manufacturer to partner on the next stage of development/scale-up and support commercialization planning.	
266	82-41	UTD Deep Energy Customized Affordabl	2023101818217	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$ 2,014,714	$0	$0	$0	Active	$0	UTD Members, DOE, Syracuse University, Hydronic Shell Technologies - $2,014,714	Operational Efficiency, In	Mid Stage (TRL 4-6)	N/A	The project aims to develop and test innovative mechanical equipment in GTI Energy's laboratory. This equipment will build upon the work under Phase 1, which focuses on developing and demonstrating innovative residential building envelope improvements, particularly deep energy retrofits and related equipment. The project will involve additional modeling and validation of the Hydronic Shell mechanical distribution system, testing Navien's new Hydro-furnace low-load single-family mechanical system retrofit, and assessing its fit with the Hydronic Shell. It will also involve developing an integrated gas-fired HVAC pod concept with space conditioning, ventilation, and potentially battery-electric storage to leverage the end-user benefits of the resilient gas distribution system. The overall goal is to integrate next-generation, high-efficiency, fuel-fired space conditioning equipment to show the continued use of fuel-fired equipment in Net Zero Buildings. Key performance indicators of success include demonstrating that a lab-tested pre-prototype of hydronic retrofit panel can maintain indoor comfort and provide efficient heating distribution for gas heat pumps (GHPs), achieving a +50% GHG reduction in at least two different integrated envelope + HVAC retrofits, submitting a modeling library item to EnergyPlus, assessing the fit of Navien's new Hydro-furnace with Hydronic Shell technology, and creating a conceptual design of a fuel-fired mechanical pod. Phase 2 of this "DECARB-EM" project leverages prime funding by NYSERDA in Phase 1, as well as potential prime financing from the U.S. DOE. UTD project 1.22.E also builds upon long-standing work by UTD under earlier project 1.11.M on residential retrofits through the US Department of Energy's Building America Research Program.	
267	82-42	UTD Emerging Distributed Methane Pyr	20231018182319	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$ 170,000	$0	$0	$0	Active	$0	UTD Members - $157,327	Reliability, Operational E	Mid Stage (TRL 4-6)	N/A	The objective of the project is to combine application/process with end-user demand modeling to classify a range of emerging distributed methane pyrolysis solutions as good, better, or best. The project team will achieve this through expanded outreach to the primary technology developers in this space, such as Modern Electron, and building on the Phase 1 effort to complete a survey of options for distributed methane pyrolysis technologies. This approach includes a techno-economic assessment (TEA) over various applications, treating the underlying conversion process, hydrogen end uses, and handling carbon outputs. Key performance indicators for Phase 2 project success include refining and executing the distributed methane pyrolysis application and process modeling plan, including scenarios in the Phase 1 TEA. Based on the process and building energy/industrial process modeling results for select applications/technologies, recommendations or follow-up proposals will be provided for UTD to advance specific technologies in good/better/best fits by end-use. The project team will complete a final TEA of distributed methane pyrolysis solutions, including at least five H2 end-use scenarios and five or more carbon output scenarios. Information and data will also be gathered regarding pilots and scale-up efforts of distributed methane pyrolysis technologies running in parallel. Over Phases 1 and 2, the project team will summarize data collected and modeling results to make recommendations to advance the technologies.	
268	82-43	UTD Energy Recovery from Brewing-Dis	20231018191170	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$ 1,470,000	$0	$0	$0	Active	$0	UTD Members, CEC - $1,460,000	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The project aims to analyze the benefits of the Waste Heat Effective Technology (WHET) for waste heat recovery and energy efficiency in potential markets such as commercial laundry operations, agriculture, and food processing. This approach extends beyond the brewery and distillery markets currently being addressed in UTD 2.21.B, which received prime funding from CEC. The project team will leverage the experience, system designs, and data collected during the field evaluation at two demonstration sites to identify the most promising additional markets for the WHET approach. It will also explore potential interest in this technology from these other markets to accelerate development and supplement a Technoeconomic Analysis performed under GTI Energy's contract with CEC. Key Performance Indicators (KPIs) for project success include a summary of WHET market applications beyond the brewery and distillery markets, assessing market size and energy savings potential, and process analyses for promising WHET applications, including sample layouts, capital costs, and operating costs. In 2023, the second demonstration site was forced to close. The team found a replacement demonstration site. The team worked with local contractors and completed the installation process for the second installation during the third quarter of 2023. Baseline testing has been achieved at the second site, and both sites are now in demonstration mode. The project team will monitor the demonstration systems' performance for a minimum of 12 months.	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	2023 Actuals (1/1-11/30/2023)	Status	2023 Estimated (1/1-11/30/2023)	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
269	82-44	UTD Energy Source Options for Industri	20231018191457	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	7/1/2023	7/31/2025	\$0	\$ 200,000	\$0	\$0	\$0	Active	\$0	UTD Members- \$189,600	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The objective of this project was to provide a robust, user-friendly analytical tool that can help decision-making, which will drive decarbonization and achievement of local environmental targets. As these end-users actively pursue reliable and cost-effective energy supply that meets environmental targets, the tool aims to provide a robust, user-friendly solution that offers clear guidance for decarbonization efforts. Key Performance Indicators of success include the incorporation of key gas-fueled industrial applications (such as furnaces and ovens) that are currently being actively proposed for electrification, scoring the decarbonization potential and economic impact related to these applications, and providing a simple user interface with clear, supportive material for easy understanding and usefulness for UTD members and customer evaluations. Phase 3 of the project will build on the results from the previous two phases. Phase 1 developed a spreadsheet-based tool, while Phase 2 transitioned the tool to an initial online version for industrial boilers. Phase 3 aims to expand to other industrial applications and further streamline the user interface and supportive materials. In 2023, the team started working to develop the tool to include furnaces and ovens as part of Phase 3.	
270	82-45	UTD Flex Fuel Gas Nozzle and Burner fo	20231018192323	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	\$0	\$ 350,000	\$0	\$0	\$0	Active	\$0	UTD Members - \$302,600	Improved Affordability, E	Mid Stage (TRL 4-6)	N/A	The project aims to design and build a 500,000 Btu/h laboratory prototype version of the flex fuel nozzle, retrofit it to an existing commercial burner at GTI, and test its flame flexibility characteristics on natural gas and an analog for alternate low carbon fuels (LCFs) such as renewable energy-derived fuels and hydrogen under simulated boiler conditions. The goal is to demonstrate that wide variations in flame size and shape can be made through on-the-fly positioning of the nozzle components. The team will test the nozzle to assess the applicability of the technology to different boilers and select process heating burners to optimize performance with both natural gas and alternate LCFs. It will also develop designs for a 3-5 million Btu/h nozzle and burner. Key Performance Indicators (KPIs) for project success include confirmation through CFD modeling that flame length and girth can be changed by at least 2:1 by fuel nozzle adjustments, validation of CFD results demonstrating the same flame length and girth can be achieved with 300 – 1000 Btu/SCF fuel with no change in air pressure drop, and maintaining a 4:1 turndown and <50 ppm CO with no stability, ignition, and flame sensing issues. Incorporating the flex nozzle should not significantly increase the design and operation complexity of the burner, and the nozzle and associated adjustment drives should add less than 20% to the cost of the burner and controls. The project also aims to pursue a US patent application and obtain an expression of interest from a major burner manufacturer to partner on the next stage of development/scale-up and support commercialization planning.	
271	82-46	UTD Hydrogen Flame Visibility and Colo	20231018182924	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	\$0	\$ 150,000	\$0	\$0	\$0	Active	\$0	UTD Members - \$116,666	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The project aims to evaluate and identify colorants for hydrogen-enriched gaseous fuel under various conditions. The objectives include establishing a matrix of hydrogen/methane mixtures to test visibility from 0% to 100% hydrogen and enhancing the safety of open-flame operation of hydrogen-enriched natural gas under four common lighting conditions with appropriate and safe gas colorants. Using gaseous colorants can allow the hydrogen/natural gas fuel to mimic natural gas flames, addressing safety concerns from gas end users regarding the appearance of hydrogen-enriched flames. Key Performance Indicators of success include assessing the flame visibility of hydrogen-enriched fuels from 0% up to 100% hydrogen addition and establishing a flame appearance map, conducting hydrogen combustion and visibility tests under at least four lighting conditions, and identifying at least two non-toxic and non-corrosive gaseous flame colorants that can be safely added into the gas transmission and storage infrastructure while enhancing hydrogen flame visibility. The project also aims to publish the results in a peer-reviewed journal or conference proceedings, demonstrate the colorant application with a manufacturing partner to develop the technology further and evaluate on a conceptual basis how a colorant might be added to a gas distribution network.	
272	82-47	UTD Impacts of Hydrogen-Blended Gas	20231018182723	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	\$0	\$ 150,000	\$0	\$0	\$0	Active	\$0	UTD Members - \$134,800	Reliability, Operational E	Mid Stage (TRL 4-6)	N/A	The project aims to assess how blending hydrogen at up to 30% and possibly higher in natural gas may impact the compliance of existing gas appliances with the National Fuel Gas Code, NFPA 54, and other key related global standards, guidelines, and building codes for flue gas venting, condensate management, and weatherized equipment. Key performance indicators for success include laboratory testing of at least three appliances or classes of appliances to identify the leading venting construction and design factors that impact good and bad combustion outcomes and flame characteristics. Factors may include vent diameter, height, length, input rate, and environment. The project also aims to develop vent tables similar to those in section 13 of NFPA 54/ANSI Z223.1 for the range of tested hydrogen blended gases and publish the results in a technical paper or a release of this project's Final Report. This project builds upon key Codes and Standards such as NFPA 54/ANSI Z223.1, the National Fuel Gas Code safety requirements for appliance installation and operation, fuel gas piping and venting systems in homes and other buildings, and applicable ASHRAE Standard requirements, forums, seminars, and research projects.	
273	82-48	UTD Inherently Safe ResCom Combustio	20231018182826	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	\$0	\$ 175,000	\$0	\$0	\$0	Active	\$0	UTD Members - \$145,526	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The project aims to ensure customer gas appliances' safe, reliable, and efficient operation with H_2-blended gas (5-50% H_2 by volume). The project team will achieve this by developing and demonstrating inherently safe combustion systems for common gas appliances such as furnaces, water heaters, and ranges and identifying inexpensive options to retrofit typical existing appliances. This approach will assist gas utilities in demonstrating hydrogen blending levels well above 5% by volume and broadly deploy blended gas in their networks. Key performance indicators of success include practical, economical combustion system designs for new and retrofit applications that can either prevent flashbacks, detect flashbacks, or shut down the burner safely. The project team will demonstrate the technology in at least three common gas appliances in a laboratory setting. The team will publish the results in peer-reviewed journals or conference proceedings and file a provisional patent(s) application. The project also aims to obtain an expression of interest from a manufacturing partner to develop further and demonstrate the technology. This project will build on prior GTI Energy research under earlier UTD-funded research, UTD 1.20.H Phases 1-3, and other industry-funded projects to investigate the limitations of blending hydrogen with natural gas in typical North American appliances.	
274	82-49	UTD Low Emission Efficient Burner for C	2023101819103	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	\$0	\$ 150,000	\$0	\$0	\$0	Active	\$0	UTD Members - \$146,600	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The project aims to design, build, and factory-test an innovative 3D-printed, UTD-patented burner at 3 MMBtu/h capacity for air heating applications such as ovens and dryers with natural gas (NG). Phase 3 will focus on installing a commercial prototype in a factory location. The technology has the potential to significantly reduce NO_x and CO emissions, reduce blower requirements, and increase efficiency. Key Performance Indicators for Phase 3 success include demonstrating high efficiency, stable ignition, and combustion characteristics, low NO_x and CO emissions, high turndown, and stable, robust operation in crossflow air in service. The overall performance is a critical proof point to convince the manufacturing partner to take the next steps to offer a commercial product. Phase 3 will build on GTI's successful previous efforts in Phase 1 with Preheat to develop the design of a burner capable of operating efficiently and robustly for process air heating applications. Before installation at the factory host site in Phase 3, final burner testing may also be performed on the process air heater testing facility at GTI. Phase 2 is testing the performance of this innovative burner with H_2-blended gas. In 2022 and 2023, an improved second prototype burner design was fabricated based on further computational fluid dynamics analysis. When tested on natural gas, it demonstrated operation at up to 6:1 turndown, very low CO emissions of below 10 ppm over the entire range of firing rates, robust ignition and stable flames, and superior NO_x performance. The team completed performance testing of both prototype designs with < 9 ppm NO_x (corr. to 3% O_2) and < 10 ppm CO (corr. to 3% O_2) emissions achieved.	
275	82-50	UTD Next Generation Commercial and R	20231018183647	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	\$0	\$200,000	\$0	\$0	\$0	Active	\$0	UTD Members - \$186,400	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	The project aims to work with commercial and residential range manufacturers to commercialize advanced range burner designs developed during the current UTD project (1.17.H Residential Cooking Indoor Air Quality – Phase 4) for cooking with natural gas and propane. Potential partners include several leading manufacturers. Key performance indicators for success include incorporating the new burner design in prototype commercial and residential ranges that demonstrate a 20% improvement in energy efficiency and a 75% reduction in NO_x emissions. Performance testing will be completed in partnership with one or more leading OEMs.	
276	82-51	UTD Technical Assistance to Advance Ga	20231018183342	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	\$0	\$120,000	\$0	\$0	\$0	Active	\$0	UTD Members, PERC - \$104,000	Reliability, Safety, Opera	Mid Stage (TRL 4-6)	N/A	This project aims to provide technical assistance and education to Commercial Food Service (CFS) and Residential Food Service (RFS) equipment OEMs, end users, and burner manufacturers on the benefits of energy-efficient equipment and potential decarbonized fuels. The project will also support the technical development of advanced foodservice equipment and systems in partnership with UTD members. The project will cover topics such as CFS COVID recovery, higher efficiency/lower emissions burner solutions, decarbonization options, energy efficiency and emissions, and advanced ventilation systems. The project will measure its success by the number of food equipment manufacturers assisted, meetings attended, technical presentations given, and tools and calculators updated or maintained. The project will target the large and stable commercial and residential foodservice market, which is a major source of revenue for utilities and a significant consumer of natural gas. The project will help maintain the advantage of gas over electric in the face of new decarbonization codes and standards. Since the CSF industry is predicted to be above \$800 billion in 2023, with growth significantly ahead of other commercial sectors, optimizing fuel sources will be essential for overall energy efficiency.	
277	82-52	UTD Zero Emission Processes with Carb	20231018192025	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	\$0	\$160,000	\$0	\$0	\$0	Active	\$0	UTD Members, DOE - \$100,000	Improved Affordability, E	Mid Stage (TRL 4-6)	N/A	The project aims to leverage Phase 1 results to develop advanced process layouts, scientific data, mass and energy balances, CO_2 capture integration configurations, and cost estimates for synthetic air combustion (SAC) processes. The goal is to prepare for submitting proposals to governmental agencies like DOE or CEC to receive large-scale funding for next-stage, scale-up technology development and demonstration efforts. Key performance indicators for success include additional validation of projections to achieve natural gas savings of 8-15%, CO_2 reduction of up to 100% when integrated with carbon capture, elimination of NO_x, delivered O_2 at a cost lower than the cryogenic route, applicability to a wide range of industrial furnaces and boilers, and identification of the most promising process configurations to integrate carbon capture for leading industry applications. Phase 2 builds upon the recent SAC work completed under earlier UTD-funded research, which focused on limited ambient temperature SAC combustion with oxygen and CO_2, and Phase 1 of UTD project 2.21.C, which tested SAC operation with synthetic air composed of oxygen, CO_2, and H_2O.	

ATTACHMENT E

Advice No. 6273-G

Track-change version of Appendix E – SoCalGas Research, Development and Demonstration Program Project Details - REVISED 2023 Research Plan

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
2	1	AVNOS Combined Water and CO2 Direct Air Capture System	20210219225633	Low Carbon Resources	Low GHG Chemical Processes	Carbon Capture, Utilization and Sequestration (CCUS)	Low GHG Chemical Processes	10/1/2020	~~9/30/2023~~ 3/31/2024	$650,000	$3,135,447	~~$425,000~~ $650,000	~~$225,000~~ $0	$157,032	Retired	$0	DOE - $2,485,447	Environmental: GHG Emissions Reduction	Late Stage (TRL 7-9)	Field demonstration/testing	The objective of this project is to demonstrate the outstanding technical and economic performance of a transformational Hybrid Direct Air Capture ("HDAC") technology that simultaneously captures CO2 and water from the air. Air is passed over a CO2 selective sorbent to remove ≥85% of the CO2 from the air stream. The atmospheric water extraction ("AWE") section of the unit utilizes a novel isothermal pressure swing regeneration cycle with desiccant beds thermally coupled by heat pipes that provide a passive heat transfer mechanism to "cancel" the heat of water vapor adsorption. By proving system performance through a demonstration project, our initial technoeconomic analysis ("TEA") will be validated, showing that HDAC technology: 1) is deployable in many more locations with limited water resources, 2) improves the financial returns, and 3) reduces risks from volatility in the price of CO2. The end goal is field testing of the HDAC unit and preparation of a final report on the testing, results, conclusions, and recommendations; and a commercial analysis of the economic viability of the system and candidate locations for commercial deployment.	
3	2	Electricore Direct Air Capture Using Novel Structured Adsorbents	20210222231948	Low Carbon Resources	Low GHG Chemical Processes	Carbon Capture, Utilization and Sequestration (CCUS)	Low GHG Chemical Processes	10/1/2020	~~9/30/2023~~ 3/31/2024	~~$300,000~~ $450,000	~~$3,715,202~~ $4,530,280	~~$200,000~~ $450,000	~~$100,000~~ $0	$62,813	Retired	$0	~~Svante - $354,356~~ ~~Climeworks - $529,846~~ ~~DOE - $2,500,000~~ Svante - $726,852 Climeworks - $704,846 DOE - $3,098,582	Environmental: GHG Emissions Reduction	Mid Stage (TRL 4-6)	Final report and demonstration	The proposed technical approach is to construct and operate an integrated Direct Air Capture (DAC) system, fielding and testing a novel combination of Climeworks' DAC process and hardware with Svante's transformational structured adsorbent laminate filter, advancing the process and identifying optimization options for this DAC configuration. Field testing will be conducted on a renewable power generation site in California to capture operational data on the novel process and material combination under real conditions. Data will be used to advise techno-economics and life cycle analysis of the technology. The objective of this project is to conduct applied research and development to address identified technical barriers on an existing, DAC system to drive down DAC cost to US$140/tCO2 for a 1Mt/y plant. A TRL 5 integrated unit will be deployed into the field for testing, producing a concentrated CO2 stream of at least 95% purity.	
4	3	PNNL Integrated CCU System (IC3M) for C1 and C2 Production Development	20210628235331	Low Carbon Resources	Low GHG Chemical Processes	Carbon Capture, Utilization and Sequestration (CCUS)	Low GHG Chemical Processes	9/1/2021	~~8/30/2024~~ 8/30/2025	$660,000	$3,300,000	~~$0~~ $660,000	~~$660,000~~ $0	$0	Retired	$0	DOE - $2,640,000	Environmental: GHG Emissions Reduction	Early Stage (TRL 1-3)	Final report	PNNL has been developing the Integrated Capture and Conversion of CO2 to Materials (IC3M) platform to make products from CO2 captured. This is a unique and promising technological pathway that can be explored in the utilization context of Carbon Capture. This project will explore C1- and C2-based material production from CO2.	
5	4	LLNL Modular Hybrid Electrobioreactor Demonstration	20220105098	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	3/1/2022	2/29/2024	~~$150,000~~ $750,000	~~$1,000,000~~ $2,030,000	~~$0~~ $375,000	~~$150,000~~ $375,000	$0	Active	$0	DOE - $1,000,000 Electrochaea - $280,000	Environmental: GHG Emissions Reduction	Mid Stage (TRL 4-6)	Final report and demonstration	The objective of this project is to scale up and deploy LLNL's in-situ electro bioreactors to determine the feasibility and economics of a commercial demonstration. In particular, goals of the project are to increase scale and productivity of current-gen reactors by at least two orders-of-magnitude, optimize electrode and flow field topology to maximize process efficiency, demonstrate successful fabrication of optimized electrode geometries, evaluate stability of the technology under variable electrical loads and variable feedstock purities, and develop technoeconomic models that will aid in demonstration of the technology.	
6	4-1	AVNOS Hybrid Direct Air Capture to Fuels Demonstration	20221025235330	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2022	10/31/2024	$500,000	$4,685,545	$375,000	$125,000	$157,032	Retired	$0	ONR - $3,935,545 Total Energies - $250,000	Environmental Benefits: GHG Reduction, Operational Efficiencies, Affordability	Mid Stage (TRL 4-6)	Final report and field demonstration	This project aims to build a commercially relevant demonstration unit to capture carbon dioxide (CO2) and water from ambient air and design a process for converting CO2 and water to zero-carbon fuels. The end-to-end method comprises IWVC's unique hybrid direct air capture (HDAC) technology and an electrically driven CO2 system to generate value-added e-fuels. The HDAC system enables self-contained (no external supplies needed, including water) production of CO2 and water. IWVC has received support from the Office of Naval Research (ONR) for this project, given the strategic importance of water and carbon-neutral fuel production for defense purposes.	
7	4-2	C4-MPC Microwave Catalysis for Process Intensified Modular Production of Carbon Nanomaterials from Natural Gas Development	2021030912832	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	5/5/2020	9/30/2024	$112,500	$3,753,721	$112,500	$0	$0	Retired	$0	DOE - $3,000,000 West Virginia University - $352,231 North Caroline State University - $176,490 H-Quest Vanguard - $150,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and prototype	The goal of this project is to design and develop a pilot demonstration microwave reactor system. C4-MCP is developing a low-cost, intensified modular process to directly convert methane into carbon-dioxide-free hydrogen and solid carbon with high conversion, selectivity, and stability. The intensified modular approach is key and will enable the unit's deployment. The method used in this project relies on using a microwave reactor to convert methane into hydrogen and carbon nanotubes (CNTs) and carbon nanofibers. Compared to other methane pyrolysis technologies, this technique demonstrates competitive energy efficiencies, regeneration of microwave catalysts, and high-quality CNT products that have the potential to offset the system's capital and operating expenses. In 2021, C4-MPC performed market and techno-economic analyses to identify commercial opportunities for the carbon nanomaterials produced in this process. To support these efforts, carbon nanomaterial products will be analyzed for their quality and potential commercial application. In 2022, the project team completed work in process optimization, catalyst development, and CNT product characterization.	
8	4-3	Captura CO2 Capture from Oceanwater Using Highly Efficient Electrodialyzer Demonstration	2021101945525	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2021	3/31/2024	$1,055,000	$1,702,267	$1,000,000	$55,000	$439,690	Retired	$28,986	Captura - $647,267	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and field demonstration	The project goal is to design, develop, and demonstrate the operation of a carbon dioxide capture system capable of extracting 100 tons/year from ocean water. Captura proposes the scale-up and testing of their technology in this project by building and demonstrating a 100-ton/year small-scale unit. The pilot aims to address the critical need to establish an integrated prototype device of the overall system at a large enough scale to assess cost levers and system scalability. In addition, the team will develop the system to demonstrate compatibility with real ocean water. The system has an ocean water intake rate of 700 gallons per minute and a carbon dioxide extraction rate of 100 liters per minute. A preliminary techno-economic analysis indicated that the Captura system could capture oceanic carbon dioxide for $500/ton at 1,000 tons/year and $100/ton at 1,000,000 tons/year. The project will test and validate the energy efficiency of capture, the purity of the captured carbon dioxide, and the stability and durability of key components in the system. The development and operation of the 100-ton/year system will provide vital data for estimating the cost of carbon dioxide capture and the scalability of the technology for a larger direct oceanic carbon dioxide capture system. In Q3 2022, the project team deployed a small-scale system at the Kerckhoff Marine Laboratory in Newport Beach, CA, to test the technology in real seawater conditions. In 2023, the group completed the primary carbon removal system fabrication and identified ocean filtration and water softening subsystems that would be required for deployment in real ocean water conditions. The team plans to complete the fabrication of the full system in early 2024.	
9	4-4	PNNL Methane Pyrolysis for CO2-Free H2 and Carbon Nanomaterials Co-Production Development - CRADA 576	20220906215850	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	10/13/2022	1/12/2024	$425,000	$425,000	$425,000	$0	$0	Retired	$0	N/A	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies , Reliability Safety, Affordability	Mid Stage (TRL 4-6)	Final report and further scale up	This project builds up on the previous project with PNNL, C4-MCP, and DOE (through the H2@Scale program). The research team now seeks to develop PNNL's highly-efficient pyrolysis process for producing CO2-free hydrogen (H2) from methane while simultaneously looking for economic viable use cases for the carbon nanomaterial co-product. The use of this technology with renewable natural gas could reduce H2's net production cost to $1.0/kg through the sale crystalline solid carbon co-products while potentially producing hydrogen with negative carbon intensity.	
10	4-5	PNNL Production of CO2-Negative Building Composites Development - CRADA 553	202106280217	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	10/1/2021	10/31/2024	$540,000	$3,240,000	$540,000	$0	$0	Retired	$0	DOE - $2,700,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report and material formulation	PNNL has developed an integrated platform to capture and convert carbon dioxide (CO2) to Materials called IC3M. It created this platform supported by a Technology Commercialization Fund partnership with DOE-FECM and SoCalGas. Production of CO2 negative composite building materials using PNNL's Integrated capture and conversion of CO2 to Materials (IC3M) will be accomplished by chemically modifying lignin in wood waste streams to durably store CO2.	
11	4-6	Stanford Energy Efficient Strategies for Capture of Atmospheric CO2	2021101951218	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2021	12/31/2023	$130,000	$130,000	$130,000	$0	$0	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report	This project aimed to continue developing sorbent technology pioneered by Stanford University, which reacts with carbon dioxide in the presence of water and requires low regeneration energy. Traditional direct air capture (DAC) systems use basic metal oxides known to bind to carbon dioxide strongly and form carbonates but need extremely high temperatures to convert back into oxides. Stanford aimed to regenerate the metal oxide sorbent's post-carbon dioxide capture to avoid using high heat. Room temperature reactions, however, require more energy to overcome the respective activation barriers. Stanford developed energy-efficient non-equilibrium plasma and plasma-activated reductants to release carbon dioxide bound in carbonates and produce carbon dioxide-derived products to regenerate the sorbent. This project's novelty was exploring non-equilibrium plasmas that exist at low temperatures, can be powered by renewable energy, and can provide a sustainable way to capture and convert carbon dioxide. In 2022, the project team developed an experimental system to evaluate the use of plasma in DAC systems. The team studied the effects of inert and reactive plasmas on efficiency and performance during operation. The team also studied side reactions and other conversion mechanisms that occurred while using reactive plasmas. Results from this initial project will be used to inform potential future research activities.	
12	4-7	Susteon High-Capacity Regenerative Structured Sorbent Development for DAC Applications	202106280308	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	9/1/2021	8/31/2023	$25,000	$1,903,877	$25,000	$0	$0	Completed	$0	DOE - $1,500,000 Total Energies SA - $200,000 Cormetech Inc. - $100,000 Columbia University - $78,877	Environmental Benefits: GHG Reduction, Operational Efficiencies, Affordability	Mid Stage (TRL 4-6)	Final report and further scale up	This project aimed to develop a structured material assembly (SMA) for capturing carbon dioxide from the air. The purpose of this project was to optimize the composition of the SMA to maximize the carbon dioxide adsorption rate, sorbent renewability, and carbon dioxide capture capacity. With this project, Susteon advanced the SMA technology from a readiness level (TRL) of 3 to 4 to justify its scale-up and pilot test in a subsequent project. The goals of the bench-scale technology projects were 1) 50% improvement of structured direct air capture (DAC) sorbent carbon dioxide working capacity over the current lab performance; 2) 50% improvement of structured DAC sorbent carbon dioxide capture rate; 3) structured sorbent pressure drop less than 150 Pa; 4) stable carbon dioxide working capacity to make certain a 3 to 5-year replacement cycle; and 5) development of a low-cost scalable fabrication process for sorbent modules. This project kicked off in Q4 2021. In 2022, Susteon designed and built a 1 kg/day CO2 bench-scale DAC test unit to evaluate the structured sorbent system's performance. The project was completed in 2023 and has demonstrated carbon dioxide adsorption at ambient conditions and subsequent desorption using electrical heating. In addition, no degradation of the sorbent bed was observed when the system performed more than 250 cycles, and the pressure drop across the SMA was consistent and below the target value. Technology scale-up will proceed with additional support from the Department of Energy and other entities.	
13	4-8	Susteon Plasma Assisted Catalytic Conversion of CO2 and Propane to Propylene and CO Development	20200629213720	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	12/1/2020	6/30/2023	$120,000	$1,120,000	$120,000	$0	$0	Completed	$0	DOE - $1,000,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report	This project aimed to develop a novel Catalytic Non-Thermal Plasma (CNTP) process to synergistically combine low-temperature plasma with metallic/bi-metallic catalysts in a scalable reactor for utilizing CO2 as a soft oxidant to produce ethylene and propylene from ethane and propane, respectively. The team pursued the following objectives under this project: 1) design and modify an existing bench scale plasma reaction system for testing the proposed process, 2) perform catalyst preparation, characterization, and evaluation under relevant operating conditions, 3) experimentally investigate carbon dioxide oxidative dehydrogenation in the plasma reactor with and without catalyst, and 4) develop process modeling activities based on experimental results. This technology is very interesting because it can offer many advantages: low-temperature operation (100° to 300°C vs. 700° to 900°C for steam cracking), quick start-up time (minutes vs. several hours for steam cracking), wide turndown ratio, smaller footprint, multiple stops and starts capability, on-demand operation, and modularity. Test results have shown that the catalysts developed under this project can obtain propane conversion as high as 60% and propylene yield as high as 80%. The team concluded that plasma-assisted catalytic conversion of CO2 and propane into propylene and carbon monoxide could be commercially viable at scale, which may create a viable carbon utilization platform.	
14	4-9	Susteon Stanford Iron-Oxide Based Catalytic Methane Pyrolysis Development	20211020154723	Low Carbon Resources	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	Carbon Capture, Utilization and Sequestration (CCUS)	11/1/2021	12/31/2023	$500,000	$3,990,139	$100,000	$400,000	$0	Retired	$0	DOE ARPA-E - $1,915,139 DOE NETL - $1,500,000	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Final report and prototype	The main objective of this project is to develop and demonstrate a methane pyrolysis unit capable of producing 10kg H2/day at less than $2 H2/kg with co-production of carbon nanotubes at under $10/kg. Stanford University and Susteon have begun developing a methane pyrolysis process to produce high-purity hydrogen and carbon nanotubes from the catalytic pyrolysis of methane. This project explores developing a unique iron-based catalyst to produce carbon nanotubes and hydrogen in a fluidized bed reactor. The team will develop a process to regenerate and reuse the catalyst and create synthesis methods that can easily be scaled to produce commercial quantities of catalyst using existing manufacturing infrastructure. The project kicked off in Q4 of 2021, and work has begun to optimize the catalyst and revise the process design. In 2022, the team made several improvements to the reactor design, including integrating structured catalyst supports resulting in much higher solid carbon recovery yields.	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
15	4-10	AIChE RAPID Institute Modular Chemical Process Intensification (MCPI) Development	20211012214631	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	9/1/2021	8/30/2024	$15,000	NA	$15,000	$0	$0	Active	$0	DOE - $60MM over the next 5 years, other members contribute between $7,500-$30,000 a year	Operational efficiencies, affordability	Early Stage (TRL1-3)	Scout early technologies that can offer ratepayer benefits if successfully scaled	This is for a membership in the Rapid Advancement in Process Intensification Deployment (RAPID) institute, an organization led by the American Institute of Chemical Engineers (AIChE) and funded by the U.S. Department of Energy. Their intent is to support the development of early technologies in processing conversion, including renewable gas production, with the ultimate goal of improving safety and operational efficiency via process intensification. RAPID's DOE funds are allocated to support development of projects executed by the different technology developers. This organization provides to the Renewable Gas Production subprogram access to technologies that can become LCR program	
16	4-11	Caltech Hybrid Electrochemical and Catalytic Hydrogen Compression System Development	20220214205939	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	12/1/2022	12/31/2024	$300,000	$2,500,000	$300,000	$0	$0	Active	$0	DOE - $2,500,000	Environmental Benefits: GHG Reduction, Operational Efficiencies, Affordability	Early Stage (TRL 1-3)	Final report and further scale up	Researchers at Caltech propose to develop a hybrid electrochemical, catalytic approach for the generation of compressed hydrogen. This technology differs from water electrolysis in that it involves a two-step process in which the active media is first electrochemically charged and then sent to a catalytic reactor to generate hydrogen directly. A benefit of this catalytic compression technology is that hydrogen can be produced on-demand with no intermediary steps at high pressure (up to 700 bar), allowing it to be stored with no additional compression or used for vehicle refueling. Low-cost hydrogen in a power-to-gas-to-power (PGP) system can help enable gigawatt (GW) scale and affordable long-duration energy storage. The project will focus on the off-peak operation to decouple and leverage renewable electricity intermittency and pricing. With data obtained during testing, the team plans to develop a comprehensive techno-economic analysis (TEA) to model the costs and performance of the system under these conditions. The project team also plans to integrate the hybrid technology to compress low-pressure hydrogen generated via water electrolysis.	
17	4-12	EvolOH High-speed AEM Electrolyzer Manufacturing Development	2022110911119	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	12/1/2022	6/30/2024	$350,000	$500,000	$275,000	$75,000	$157,032	Active	$0	EvolOH - $150,000	Environmental Benefits: GHG Reduction, Affordability	Mid Stage (TRL 4-6)	Final report, further scale up, and commercialization	This project aimed to develop high-speed coating methods for anion exchange membrane (AEM) electrolyzer technology to increase overall manufacturing speed and capacity. EvolOH's electrolyzer technology combines the performance advantages of proton exchange membrane (PEM) electrolysis (pure water feed, fast response, load-following, pressurized hydrogen production) with the cheap, non-platinum group metal (PGM) materials used in traditional alkaline electrolysis. EvolOH has designed its technology to accommodate roll-to-roll manufacturing, which can achieve nearly an order of magnitude improvement in production rate over state-of-the-art electrolyzer manufacturing methods. Increasing electrolyzer production speed and reducing material costs represent a meaningful strategy to lower the levelized hydrogen costs and increase the domestic supply of hydrogen production equipment. The project team achieved high-speed coating in this process, previously identified as a major manufacturing bottleneck. The team also validated the performance and stability of electrolyzer cells and stacks developed using this production technique. In particular, the project team developed new and improved catalyst ink formulations, demonstrating improved performance and processability. As part of this project, EvolOH also participated in a third-party techno-economic analysis to validate their anticipated stack material and manufacturing costs and understand the cost savings that may be realized as they increase the manufacturing scale.	
18	4-13	Kore Biosolids Pyrolyzer Field Test	178111287	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	2/13/2017	3/31/2023	$1,500,000	$5,300,000	$1,500,000	$0	$376,877	Completed	$0	Kore Infrastructure - $3,600,000 SCAQMD - $1,000,000	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Late Stage (TRL 7-9)	Final report and demonstration	This project aimed to reduce risk and improve the potential for financing future commercial deployments by conducting field tests to verify component integrity at high temperatures, feedstock throughput, and gas product quality and composition. Kore Infrastructure developed a commercial-scale pyrolyzer that thermochemically converts biomass to syngas. The produced syngas—a mixture of methane, carbon monoxide, carbon dioxide, and hydrogen—can be converted to renewable natural gas or renewable hydrogen. The pyrolyzer also has the potential to accept and process waste streams, including forest thinning, municipal solid waste, and food waste. The project team demonstrated the operation of feedstock conveyance and drying, pyrolytic conversion, and gas cleanup and cooling. Construction at SoCalGas' Olympic Base concluded in late 2021. Commissioning activities for the pyrolyzer began immediately afterward. System operations and testing began in 2022. Kore gathered operation data on system performance to guide future development and deployment activities. After multiple successful system runs and data-gathering activities, the team decommissioned the system in Q1 2023.	
19	4-14	Linde HydroPrime HC300 (Distributed Steam Methane Reformer - SMR) Purchase for Integration with STARS and Other Low Carbon Hydrogen Technologies	2019110314642	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	11/15/2019	12/31/2023	$2,675,566	$5,675,566	$2,405,966	$254,600	$0	Active	$0	FirstElement Fuel - $3,000,000	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Late Stage (TRL 7-9)	Final report and demonstration	The project's objectives are to 1) deploy the Linde HydroPrime MIN HC300 hydrogen plant capable of producing up to 300 Nm3/hr of hydrogen and 2) support the integration of the Solar Thermal Reactor System (STARS) steam methane reformer (SMR) with the Linde plant. This integration will enable researchers to interchange the Linde-supplied reformer component of the HydroPrime MIN HC300 hydrogen plant with the STARS unit and other advanced SMR technologies. The integrated system will utilize the balance of plant components - water shift reactor, pressure swing adsorption, heat exchangers, gas processing, instrumentation and controls, and electrical - of the HydroPrime MIN HC300 hydrogen plant to handle and process both the feed stream and syngas output stream of the STARS unit and other advanced SMR technologies. Successful integration will demonstrate and validate the production of a pure hydrogen output stream using several advanced SMR technologies.	
20	4-15	NREL Biologically Derived Hydrogen From Organic Solid Wastes Research	20221101232254	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	12/1/2022	4/30/2024	$189,320	$394,320	$189,320	$0	$0	Active	$0	DOE HFTO - $180,000 NREL - $25,000	Environmental Benefits: GHG Reduction, Affordability	Early Stage (TRL 1-3)	Final report	The goal of this project is to test and identify suitable feedstocks for biotechnology developed at the National Renewable Energy Laboratory (NREL) that can produce hydrogen from organic solid waste streams rich in cellulose content. The core of this technology employs microbial, dark fermentation to harness the chemical energy and electrons in these wastes for hydrogen production. The NREL team has leveraged their expertise in microbial strain engineering and bioprocess design to create strains of Clostridium thermocellum and develop fermentation strategies that achieve high conversions of the organic solid waste streams to hydrogen. The project team plans to test their engineered microbes to enhance anaerobic digestion (AD) technologies by further processing cellulose-enriched "hard-to-digest" materials into hydrogen. These wastes may be from less complex sources (e.g., dairy residues) or highly complex sources (e.g., biosolids or sludges produced during municipal wastewater treatment). This carbon-neutral approach can potentially be carbon-negative when paired with carbon capture technologies. In addition to the ongoing work to evaluate these feedstocks, the project team will also work with researchers at Argonne National Laboratory to perform a detailed techno-economic analysis for this hydrogen production pathway. In 2023, the team sourced >10 unique waste biomass feedstocks and screened their activity for hydrogen production. Additional activities included compositional analysis to quantify the chemical makeup of the feedstocks which will inform further research, such as microbial strain modification, in 2024.	
21	4-16	NREL CRADA No. CRD-19-809 P2G Systems Integration & Optimization	20190415153550	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	5/1/2019	10/4/2024	$3,000,000 (in-kind)	$3,700,000	$3,000,000	$0	$6,281	Active	$0	DOE - $700,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Final report and field demonstration	The goal of this project is to integrate biomethanation and electrolysis to realize the synergies that the two processes have. Hydrogen's inherently low solubility in water can challenge power-to-gas biomethanation and other gas fermentation processes. This low solubility limits the availability of hydrogen to the biocatalyst. The methods are also burdened by the high capital costs of the water electrolyzer used to make green hydrogen. The National Renewable Energy Laboratory (NREL) is working to eliminate expensive hardware unnecessary in producing hydrogen for this purpose. By co-locating the electrolyzer with a chemical reactor, some of the sub-systems normally needed to produce pure "dry" hydrogen, which is necessary for fueling but not for processes like biomethanation can be removed. This approach could avoid thousands of dollars in equipment costs while improving system efficiency by preventing hydrogen losses or additional energy to dry the gas. These improvements resulted in a non-provisional patent application in 2021. During 2021, NREL completed the electrolyzer balance of plant design for the mobile biomethanation system and incorporated these innovations ahead of receiving a 20kW electrolyzer stack from Plug Power. In 2022, the team completed the advanced electrolyzer system design, removing unnecessary sub-systems and implementing a novel strategy to measure hydrogen flow rate using stack current from the electrolyzer. The team also worked with the University of Chicago and Perma Pure to develop technology to recycle water in the biomethanation reactor.	
22	4-17	NREL Multi-Party CRADA No. CRD-18-00775 Biomethanation to Upgrade Biogas to Pipeline Grade Methane	2019062123830	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	7/31/2019	3/6/2024	$644,900 (in kind)	$2,265,000	$644,900	$0	$0	Active	$0	NREL - $1,500,000 Electrochaea - $120,100	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Final report and field demonstration	This project aims to develop and de-risk an adaptable biomethanation process to upgrade biogas waste streams to renewable natural gas (RNG). The team designed and specified a lab-scale biomethanation bioreactor and the balance of plant needed to produce pipeline-quality RNG from biogas and green hydrogen. They based the design on lessons learned from operating the SoCalGas 700L bioreactor system at the National Renewable Energy Laboratory (NREL). In 2021, NREL designed and Parr Instrument Company built the lab scale 20L 18-bar pressure-rated bioreactor. They outfitted it with multiple ports for sensors. The bioreactor also includes multiple sight glasses for viewing and a high-speed camera to monitor gas mixing. The team will install the bioreactor in a custom 16' trailer that will travel to biogas sites to demonstrate the production of RNG. Data from this mobile system will be available to regulators to accelerate the certification of the RNG production pathway from biomethanation. In 2022, the NREL team worked with Argonne National Laboratory researchers to develop a life cycle analysis for the RNG produced from biomethanation. One major takeaway of this study was that the carbon intensity (CI) score of RNG produced via this pathway heavily depends on the CI and source of electricity used to power the electrolyzer. When using a fully renewable electricity supply, RNG made from biomethanation of swine manure-derived carbon dioxide is ~-100 g CO2eq per MJ, demonstrating carbon-negative fuel production. The new mobile bioreactor system is expected to be operational and deployed to biogas sites by the end of the 2023 calendar year.	
23	4-18	STARS Corporation Electric Induction Steam Methane Reforming (SMR) Demonstration	2020031815556	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	4/1/2020	12/31/2023	$3,600,000	$7,500,000	$3,275,000	$236,303	$88,697	Active	$0	STARS - $3,900,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Mid Stage (TRL 4-6)	Final report and demonstration	The goal of this project is to demonstrate and deploy a novel, advanced steam methane reforming (SMR) process to produce renewable hydrogen. STARS Corporation is developing an advanced, highly efficient SMR reactor that utilizes electrical induction-based heating instead of combustion heating, eliminating NOx formation. STARS' reactor design uses micro and mesoscale catalytic channels and efficient heat recycling to demonstrate record efficiencies in converting electrical energy and natural gas to produce hydrogen. STARS' reactor technology features modularized construction capability and a small footprint. This technology will support on-site storage and fueling operations for SunLine Transit's fleet of hydrogen-powered buses in Thousand Palms, California.	
24	4-19	Susteon Catalytic Non-Thermal Plasma (CNTP) Reactor Scale-Up Demonstration	20210628063	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	8/1/2021	6/30/2023	$500,000	$500,000	$500,000	$0	$191,903	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and further scale up	The goal of the project was to continue the development of the catalytic non-thermal plasma (CNTP) technology by building up a reactor capable of producing 10kg of hydrogen per day. This project follows up on CNTP technology developed in a previous project with the Jet Propulsion Laboratory, in which the technology was successfully demonstrated at lab scale. The CNTP reactor uses plasma to improve the conversion of methane and water into a hydrogen-rich syngas at much lower temperatures relative to other steam methane reforming technologies. Susteon also tested the use of the CNTP reactor in the production of sustainable aviation fuel from carbon dioxide and methane, which would create an opportunity for utilization of captured CO2 to provide a new pathway to reduce greenhouse gas emissions in an otherwise difficult-to-decarbonize sector. The research team successfully operated the CNTP reactor using commercial nickel catalysts to demonstrate a hydrogen-rich product gas from methane and steam at 450oC for 200 hours. A 3-fold increase in methane conversion was observed with the introduction of plasma, reaching around 60% methane conversion. The team also investigated the use of the CNTP technology for Sustainable Aviation Fuel (SAF) production and collected important insights to direct the future investigation of this route. An updated techno-economic analysis (TEA) was also performed, resulting in a H2 cost of around $2.65/kg.	
25	4-20	TCF-19-17586 LLNL Composite Sorbents - Enabling Economical Biomethane Production	20190912143734	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	10/15/2019	7/29/2024	$500,000	$750,000	$250,000	$250,000	$0	Active	$0	DOE - $250,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final report and demonstration	The goals of this project are to determine the economic and technical feasibility of a full-scale demonstration after the two-year project. Lawrence Livermore National Laboratory (LLNL) and SoCalGas are working to refine and demonstrate a new class of sorbents for upgrading raw biogas to biomethane. This approach offers the potential to reduce cost barriers to biomethane production significantly. This strategy would, in turn, allow small producers to leverage this renewable energy resource to generate revenue. The focus of the technology maturation activities are to 1) demonstrate the longevity of the sorbent over an industrially relevant time scale; 2) understand the effects of hydrogen sulfide contamination; 3) scale up sorbent production; and 4) scale up the system by approximately four orders of magnitude. In 2020, LLNL devised a new composite material formulation compatible with large-scale manufacturing and built and operated a lab-scale unit (LSU). The LSU is a bench-top, integrated, automated sorbent system suitable for long-term (1,000-hour) testing. In 2021, LLNL planned activities with Xebec to operate a small-scale pilot (SSP) of the LSU at Xebec's testing facility. In 2022, LLNL successfully scaled up sorbent production for use in the SSP. The target completion date for the SSP will be 2023. LLNL will produce a techno-economic analysis of SSP for future maturation activities.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
26	4-21	UCR Speeding Anaerobic Digestion Through CO2 Microbubbles	20200513161417	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	6/1/2020	12/31/2023	$149,877	$299,877	$149,877	$0	$0	Completed	$0	CalSEED - $150,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Final report and demonstration	This project aims to introduce carbon dioxide microbubbles to increase methane generation rates in anaerobic digestors significantly. The project team collaborates with Riverside Water Quality Control Plant, which has sufficient digestion capability to dedicate two one-million-gallon digesters to this trial. One digester will serve as a control, and the team will operate it normally. The second will be the experimental digester with the Perlemax technology implemented into its heat exchanger recirculation loop. The team will compare results from the experimental digester to those of the control to determine if the carbon dioxide microbubbles statistically affect digestion rates. Initially, both digesters will start with the same sludge feed rate. The experimental digester will begin with a low flow of carbon dioxide microbubbles. The team will optimize sludge and carbon dioxide flow rates to maximize volatile solid conversion and methane production. Early in the project, the team completed the design and fabrication of the microbubble equipment. In 2023, the project team faced long delays due to an industry-wide shortage of carbon dioxide. A suitable carbon dioxide supplier was finally identified late in 2023. Installation, commissioning, and equipment testing will be completed in 2024.	
27	4-22	West Biofuels Renewable Gas Separation System and Techno-Economic Assessment	20190911193025	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	10/1/2019	12/31/2023	$200,000	$2,200,000	$200,000	$0	$0	Completed	$0	CEC - $2,000,000	Environmental Benefits: GHG Reduction, Affordability	Early Stage (TRL 1-3)	Final report and demonstration	The objectives of this project are to 1) assess the separation efficiency of gas hydrates in producing high-purity renewable methane from mixed alcohol tail gas and 2) to develop an integrated techno-economic model to calculate production costs and identify key cost drivers within the West Biofuels biomass-to-mixed alcohol process. Ongoing experiments validated the proof-of-concept by showing that, under appropriate thermodynamic conditions, gas hydrates selectively concentrate methane and higher molecular weight species within the mixed alcohol tail gas stream. Despite this validation, both the time necessary for hydrate formation and the lower-than-desired per-stage separation efficiency suggest that alternative or supporting separation processes may be required. Modeling efforts have focused on modifying existing National Renewable Energy Laboratory (NREL) mixed alcohol production models to reflect recent process modifications. In 2021, applying the gas hydrate separation concept in the continuous flow arrangement showed promise, meriting further investigation. Furthermore, other separation technologies—membrane and pressure swing adsorption—are being investigated to make sure successful project completion. In 2022, despite significant downtime due to equipment damage, repair, and supply issues, the team recommissioned the system to begin long-term testing runs, data collection, and analysis activities. Using data from these runs and natural gas separations modeling support from NREL, techno-economic analysis will be refined and reported in 2023.	
28	4-23	HyET Hydrogen -- Electrochemical Hydrogen Compression and Purification Skid Procurement	20200309233424	Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	Renewable Gas Production	3/9/2020	10/31/2023	$651,245	$651,245	$651,245	$0	$41,745	Completed	$0	N/A	Reliability, Safety, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordabilitiy	Mid Stage (TRL 4-6)	This HyET unit was decommissioned, removed from the host site, and stored. A new generation of this technology is being developed based on the learnings from the project.	HyET's Electrochemical Hydrogen Purification & Compression (EHPC) technology is based on the selective transport of hydrogen through a membrane electrode assembly. The primary objectives of this project were to procure a pilot EHPC skid to demonstrate the technology and to collect valuable performance data to help improve the efficiency and capital cost of the EHPC system in future commercial applications. The EHPC systems were designed for a nominal hydrogen production capacity of 10 and 100+ kg of hydrogen per day for a pilot and commercial scale, respectively. In 2021, the HyET EHPC skid was delivered to and successfully installed at SoCalGas' Engineering Analysis Center. Preliminary testing was completed and the unit is operating as designed, successfully demonstrating hydrogen extraction. The unit's operation is ongoing and continued to provide valuable testing data while blending hydrogen, in concentrations from 3 to 15%, with methane in a simulated pipeline environment. The equipment was decommissioned and removed from the host site in 2023, and a new generation of this technology is being developed based on the learnings from the project.	
29	GO1	Aboveground Service Tee Identification and Mapping System (8.20.j)	2.0201E+13	Gas Operations	Environmental & Safety	_	Safety - Damage Prevention	2/1/2021	2/16/2023	$25,287	$220,000	$25,287	$0	_	Completed	$0	SCG $25,287.00 | OTD Members $194,713.00	Safety	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to test and demonstrate a three-dimensional electromagnetic technology to locate subsurface metallic infrastructure such as metal cutters in polyethylene (PE) service tees. Most locating technologies do not have high-accuracy antennae to find underground facilities with high confidence, much less with plastic. Knowing the precise locations of buried infrastructure has the potential to save money by mitigating dry-hole excavations. In 2021, the team used the project data to determine the accuracy and effectiveness of the pipe-locating technology in identifying metallic cutters in buried PE service tees, which generates an intrinsic and unique fingerprint. In 2022, sponsors provided a variety of service tees that were classified and tested, with the system yielding positive results of geospatial accuracy and pipe depth. The data was collected and analyzed to determine the accuracy of the 3D position (latitude, longitude, depth) of the service tee cutter and to distinguish the service tee cutters from other metallic anomalies, such as emplaced clutter, against data in the library. The project team found that the emplaced clutter creates a fingerprint that is not unique to any tee cutter and instead creates a false positive. Upon project completion, the team will present the results in a webinar and deliver the testing and field demonstration reports to sponsors. SoCalGas could benefit from the ability to locate subsurface metallics because it has the potential to reduce damage to its lines, which reduces damage to life, property, and community. .	_
30	GO2	AERMOD NO2 Modelling Improvement Project-Dissemination of Results (CPS-11-5B)	20221007182248	Gas Operations	Environmental & Safety	_	Environment	12/14/2022	2/13/2024	$34,050	$61,732	$34,050	$0	_	Active	$0	SCG $34,050.00 | PRCI Members $27,682.00	Improved Affordability and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Share/Publish Results	The project objective is to assess the performance of the American Meteorological/Environmental Protection Agency Regulatory Model (AERMOD), the U.S. Environmental Protection Agency's (EPA) compliance tool for estimating impacts from air pollutant emission sources. This model overestimates ground-level NO2, which could lead to unnecessary NOx reduction system retrofits and compressor unit replacements. Previously, SoCalGas worked with Pipeline Research Council International (PRCI), the Interstate Natural Gas Association of America Foundation, the American Petroleum Institute, and other trade associations to build a robust emission dataset to assess the AERMOD model and to develop recommendations for improving AERMOD. The project team also identified pathways and methodologies to enhance model impact estimates from reciprocating engines, completed additional analyses, and recommended model changes. In this phase of the project, PRCI and sponsors will support EPA as they implement model changes and present the results in a workshop disseminating the AERMOD modifications to the public. The knowledge transfer involves in-person and web meetings with EPA staff and supports an EPA specialty conference involving AERMOD experts in a panel discussion. A tool that accurately assesses emissions could assist in planning for air emission reductions.	_
31	~~5~~	~~Centrifugal Dry Gas Reliability Enhancement IV (CPS-5-10A)~~	~~20220427201225~~	~~Gas Operations~~	~~Environmental & Safety~~	_	~~Environment~~	~~4/13/2022~~	~~7/12/2022~~ ~~4/13/2023~~	~~$3,734~~	~~$29,500~~	~~$0~~	~~$3,734~~	-	~~Completed in 2022~~	$0	~~SCG $3,734 | PRCI Members $25,766~~	~~Reliability, Safety, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality~~	~~Late Stage (TRL 7-9)~~	~~• Share/Publish Results~~	~~Dry seals are critical components in preventing release of GHG in centrifugal compressors. These seals, however, are known to fail resulting in releases in GHG to the environment and causing centrifugal compressor shutdowns that cause service interruptions. This project will investigate the causes of seal failures. In previous phases under GMRC which PRCI did not participate in, the project team used test rigs in the laboratory to collect data on seal performance and factors that caused seal failure. Those data were used in a model simulation to predict failure and causes. In phase IV, the team will continue its root cause analysis on seal failure modes based on operational parameters as well as seal materials. This additional phase will help improvements in the predictability model for seal performance that minimizes seal failures and prevents accidental release of GHG to the environment. At the end of the project, a final report will be delivered along with the seal failure predictive model to sponsors. The results of research will also be dissimilated to seal manufacturers to improve seal design and performance. SoCalGas could benefit in the future from better and more reliable seals as well as other utilities who operate centrifugal compressors. Ratepayers would also benefit with safer and less risk of disruptions in their energy supply.~~	-
32	GO3	CEPM for Turbochargers (CPS-14B-08)	2017092264	Gas Operations	Environmental & Safety	_	Environment	1/31/2019	3/31/2023	$8,653	$102,101	$8,653	$0	_	Completed	$0	SCG $8,653.00 | PRCI Members $93,448.00	Reliability, Improved Affordability, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop turbocharger performance models from the data collected from a variety of past PRCI projects, as well as new data collected at two compressor stations. The model will provide operators with technology capable of early detection of decreased natural gas engine turbocharger performance. This approach will enable them to schedule maintenance and repairs before the engine cannot meet emissions limits. The team completed model development in 2020. Closures related to the ongoing COVID-19 pandemic delayed the collection of additional data needed to refine the model and perform validation testing. In August 2021, the project team completed data collection and used the information to validate the performance monitoring model. The team finished the validation of the turbocharger model in 2022. However, the team encountered a problem with one of the two models, the turbine model, used in the overall turbocharger performance model. The turbine model requires further refinement to improve performance predictability. This problem has resulted in the team moving the completion date to the end of the first quarter of 2023. The final deliverable for the project will be a final report and the models to predict turbocharger performance. SoCalGas could utilize the models to support compressor management to improve turbocharger performance.	_
33	~~6~~GO4	Development and Evaluation of High Resolution Historical Climate Dataset Over California (GFO-19-501, Group 2)	2021010815138	Gas Operations	Environmental & Safety	_	Environment	6/30/2020	3/31/2024	$5,000	$1,368,550	$2,500,682	~~2500~~ $2,318	$182	Active	$0	SCG $5,000 | CEC (GFO-19-501) $1,363,550	Reliability and Safety	Late Stage (TRL 7-9)	• Deployment of Results • Share/Publish Results	Weather forecasting models are used to find utility infrastructure vulnerabilities in extreme weather events. Examples of such events include extremely dry conditions posing wildlife threats and extremely wet conditions causing floods and mudslides. The two climate models currently used for forecasting are: (1) West Weather Research and Forecasting Model for California "dry" simulations, and (2) Desert Research Institute's Weather Research and Forecasting model for California "wet" simulations. A California Energy Commission (CEC) project titled, "Development of High Temporal and Geographical Resolution Characterization of Historical Climatic Conditions in California (CEC GFO-19-501, Group 2)," was awarded to UC San Diego and Scripps Institution of Oceanography. It will assemble climate data from California between 1980 to 2019 to be used to improve both models for forecasting weather conditions. The goal is to provide models that will enable utilities to assess infrastructure risks associated with exposures to short-term and long-term extreme weather events. The datasets will be made available in the cloud to utilities and climate researchers. The model results will also be made publicly available. The project team has started compiling the datasets for higher resolution refinements. SoCalGas is participating on the Technical Advisory Panel for the project.	
34	~~7~~	~~Fuel Reforming and Segregation as an Alternative for Compressor Fuel (GHG-SRP CPS-14-07)~~	~~20210408133828~~	~~Gas Operations~~	~~Environmental & Safety~~	_	~~Environment~~	~~3/16/2021~~	~~8/19/2022~~ ~~3/16/2023~~	~~$12,905~~	~~$289,100~~	~~$5,682~~	~~$7,223~~	-	~~Completed in 2022~~	$0	~~SCG $12,905 | PRCI Members $276,195~~	~~Environmental: Improved Air Quality and Environmental: Improved Air Quality~~	~~Early Stage (TRL 1-3)~~	~~• Further Technology Development/Prototype~~	~~This Pipeline Research Council International greenhouse gas strategic research priority (GHG-SRP) project studies the use of hydrogen as a fuel to run compressor engines, and focuses on large bore, slow speed lean-burn engines. Compared to fossil-fueled methane, hydrogen fuel has the advantage of not producing GHG emissions. The first tasks are to conduct a literature review and to produce a whitepaper. These will investigate methane reforming technologies to produce hydrogen fuel, and will explore how hydrogen-blended fuel affects engine operations, performance, and emissions. Methane reforming uses methane as a feedstock in a chemical process to generate hydrogen. In petroleum refining, a steam reformer and water-shift reactor are used to produce hydrogen for desulfurizing fuels. The first phase of this project looks at new and existing steam reforming technologies and compares the advantages and disadvantages of each. From this comparison, a technology will be selected to be used to produce hydrogen for compressor engines for laboratory evaluation, prototype development, field evaluation, and durability assessment. This project will also look at how hydrogen blended fuel will affect engine efficiency, GHG emissions, and NOx emissions. Prior research on methods of controlling the engine to accommodate varying levels of hydrogen and combustion modeling will be investigated. This work dovetails with other projects investigating the reduction of methane in engines exhaust. The goal is to reduce GHG emissions from compressor engines. The results of the study could lead to using hydrogen or hydrogen-blended fuels as a fuel for compressor engines including from SoCalGas's compressor engines~~	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
35	GO5	Gap Identification Between Hydrogen & Natural Gas Pipelines Standards & Practices (5.21.s)	2021062216838	Gas Operations	Environmental & Safety		Safety	8/1/2021	9/30/2023	$5,502	$170,000	$5,502	$0		Completed	$0	SCG $5,502.00 | OTD Members $164,498.00	Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Share/Publish Results	This Operations Technology Development project aims to identify gaps in regulations and other safety and industry standards where pipeline transport of H2-NG blends may not be addressed and potential solutions to address the gaps. Parts 190, 191, and 192 of Title 49 of the Code of Federal Regulations address safety and other requirements for transporting natural gas by pipeline. Natural gas pipelines are also covered by additional safety and industry standards (e.g., American Society of Mechanical Engineers, International Organization for Standardization). SoCalGas has prioritized reducing its carbon footprint and greenhouse gas emissions and is investigating using hydrogen-natural gas (H2-NG) blends to achieve this goal. It is, therefore, important to understand how these blends could impact SoCalGas' pipeline operations. The project team completed all tasks except the interviews with national and international hydrogen system operators and natural gas utilities investigating, experimenting, or looking to implement H2-NG blending, which will be scheduled and completed in Q1 of 2023. Upon completion of interviews, the team will compile all applicable codes and standards into a spreadsheet with an associated abstract summary for a gap analysis. The team will publish the results in a whitepaper that includes all hydrogen and H2-NG codes, standards, and practices; a gap analysis of H2-NG blending; and recommendations for H2-NG blending guidelines and best practices. SoCalGas will use the results of this research to develop and update its standards and best practices for hydrogen and H2-NG blends, supporting the safety, reliability, and efficiency of H2-NG operations. The results could also lead to the development of statewide hydrogen and H2-NG blending standards.	Hydrogen-Blending Project The project was completed prior to Resolution.
36	~~8~~GO6	Greenhouse Gases Emissions Reduction (SRP-GHG-01)	20210720172927	Gas Operations	Environmental & Safety		Environment	1/1/2021	12/31/202~~3~~4	$32,339	$3,838,835	~~11368~~ 32,339	~~20971~~ 0		Active	$0	SCG $32,339 | PRCI Members $3,806,496	Environmental: Reduced GHG Emissions	Mulitple - Program supports various projects.	• Mulitple - Program supports various projects.	Greenhouse gas (GHG) emissions are a global issue and have impact on the natural gas industry. Pipeline Research Council International established a Strategic Research Priority (SRP) to coordinate the efforts across all technical committees. The SRP goal is to provide a roadmap of projects researching means to significantly reduce GHG emissions from the natural gas transmission system. This information will provide the natural gas industry with GHG reduction solutions to implement and reduce its carbon footprint. The SRP funded and started eight projects in 2021: Regulatory Support for GHG Emission Reductions (CPS-11-09), Continuous Monitoring and Diagnostics for Facility Efficiency (CPS-14-06), Methods to Reduce Pipeline Blowdowns to Effectuate Repairs/Inspections (MATR-3-15), Flow Sensors for Continuous Monitoring and Diagnostics for Equipment Efficiency Monitoring (MEAS-5-28), Methane Leak Detection and Quantification (PL-1-08), and CPS-14-05 CFD Study of Prechamber Ignition Mechanism for GHG Reduction. More details can be found in the individual project summaries for: Fuel Reforming and Segregation as an Alternative for Compressor Fuel (CPS-14-07), Improvements in Facility Efficiency (CPS-17-07), and Reciprocating Engine Exhaust Methane Slip Reduction (CPS-17-08). In addition to the projects that started in 2021, two ideas are being considered for projects under GHG SRP: Low-Cost Instruments to Detect/Quantify Leaking Seals, Packings, or Dump Valves, and High Flow Sampler Replacement.	
37	GO6	Identify and Validate Best Practices for Applying Heat to Steel Near PE (5.19.s)	2019082322145	Gas Operations	Environmental & Safety		Safety - Damage Prevention	10/3/2019	3/31/2024	$103,117	$203,617	$103,117	$0		Active	$0	SCG $103,117.00 | OTD Members $100,500.00	Reliability and Safety	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing; Modification to Regulatory, Policy & Standards; Deployment of Results; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to identify and validate best practices for applying heat to steel near polyethylene (PE) material. Field welding of steel pipeline components can transfer heat to adjoining PE material and affect its integrity. This study will consider possible worst-case scenarios in the field and the associated parameters needed to create a model that allows the user to simulate field conditions and predict the risk of heat damage to plastic facilities. The team worked on developing a preliminary simulation model with improvements aimed at reducing computational time. The team verified the physics behind the simulation. The project team is also developing and validating a standalone heat transfer calculator. It will include user inputs of critical parameters of welding, heat, pipe size, and local field conditions. The model will then calculate and display the maximum temperature at the PE-steel pipe interface. The calculator will also display a graphical representation of the 3D model. In 2022, the project team continued to fine-tune the conjugate heat transfer Multiphysics model and started the validation testing. This project benefits SoCalGas in reviewing and confirming best practices outlined in Company standards for welding near PE pipe, along with ensuring the integrity and safety of PE pipelines.	
38	GO7	Impact of Trace Constituents on Odor Masking (7.21.c)	20210127231347	Gas Operations	Environmental & Safety		Safety	3/1/2021	4/30/2024	$17,578	$150,000	$17,578	$0		Active	$0	SCG $17,578.00 | OTD Members $132,422.00	Safety	Early Stage (TRL 1-3)	New Research Project to Advance TRL,	The objective of this study is to identify trace constituents that act as odor-masking agents. Natural gas contains numerous chemicals that are removed at gas processing plants before injection into the natural gas pipeline system. After treatment, trace amounts of these chemicals still exist in the processed gas. Some of these chemicals may act as odor-masking agents, preventing people from smelling gas leaks. The industry will use the study's results to determine how to mitigate the masking effect of these agents. The effort will lead to safer gas operations for utility workers and their customers. In early 2021, the team developed an odor masking test method to examine seven common masking agents found in gas processing plants. The team completed testing, and they identified the trace constituents of concern. Volunteers in laboratory sniff tests were to be employed to test those trace constituents. However, the project team delayed this last stage of the project due to health protocol concerns. The team is actively addressing the issues and anticipates that they will complete the sniff test in Q1 of 2023, along with the final report. Once SoCalGas receives the results, it will use them to determine if it needs to change its odorant program to protect ratepayers.	
39	GO8	Improving HCA Classification Methods (8.21.f)	20210111174145	Gas Operations	Environmental & Safety		Safety	3/1/2021	5/24/2023	$37,360	$184,000	$37,360	$0		Completed	$0	SCG $37,360.00 | OTD Members $146,640.00	Safety and Operational Efficiency	Early Stage (TRL 1-3)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing; Technology & Knowledge Transfer/Training;	The objective of this project is to improve the accuracy of classifying high-consequence areas (HCA) and moderate-consequence areas (MCA) through modern data analysis and data sources. An HCA is an area where a release of natural gas would adversely impact the health and safety of the affected population. The current methodology used to define consequence areas is set by Pipeline and Hazardous Materials Safety Administration. This methodology allows for using outdated data that do not factor in population dynamics or development patterns in and around urban areas. Disregarding these fluctuating patterns in the model creates the potential for some areas to be misidentified. This misclassification exposes the impacted areas, the utility, and the general population to unnecessary risk. This project will explore the use of modern data sources and develop algorithms to automate the quantification of population or building use and size. In 2022, data acquisition and processing for the project study area continued. Additionally, the project began the data analysis by comparing the satellite vendor's building structure data to the project sponsor's data. SoCalGas intends to use this research to 1) enhance monitoring efforts in locating facilities that affect HCAs and MCAs and 2) explore alternative methods of monitoring the pipeline right-of-way for improving safety and compliance processes in accurately identifying HCAs. .	
40	~~29~~GO9	Living Lab for Hydrogen (M2021-008)	20210803205350	Gas Operations	Environmental & Safety ~~System Design & Materials~~		Safety ~~System Design~~	12/13/2021	12~~6~~/28/202~~4~~6	$300,000	$1,222,402	~~67667~~ 95,629	~~232333~~ 204,371	$27,962	Active	$0	SCG $300,000 | NYSEARCH Members $922,402	Reliability, Safety, Operational Efficiency, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	• Deployment of Results • Share/Publish Results • Technology & Knowledge Transfer/Training	The goal of this project is to analyze and report data on the impacts of hydrogen blending at higher percentages (i.e., greater than 20 vol%) by evaluating safety, maintenance, and emergency response changes on gas distribution infrastructure and appliances. This is a SoCalGas project co-funded by NYSEARCH. The Living Lab demonstration aims to validate the feasibility of blending and injecting 20% or more hydrogen by volume into the existing natural gas infrastructure by simulating system operations with steel and plastic pipelines, a pressure regulator station, a compressor, and various end-use equipment. This project will yield valuable data on impacts to pipeline integrity, measurement, regulation, end-use equipment, and safety and maintenance procedures. .	Hydrogen-Blending Project 1) This project is necessary to research practical hydrogen blending limits on pipeline components to provide industry-wide benefits and influence the creation of SoCalGas standards and operating procedures. 2) This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: a) Evaluating H2 blend impacts on both medium (40 psig) and high pressure (100 psig), whereas our hydrogen blending pilot projects will evaluate H2 blending impacts on medium pressure systems only (greater than < 60 psig). b) Evaluating H2 at high concentration, from 25 vol% to 35 vol% H2, whereas our demonstration projects will evaluate H2 blends from 0.1 vol% to 20 vol%. c) Evaluating H2 blending impacts on a compressor, whereas our demonstration projects won't have a compressor component. d) Providing hands on, long-term, detailed data collection not possible with large scale demonstration projects (e.g. removing pipe components for inspection). SoCalGas has requested the use of clean renewable hydrogen to be included this projects scope.
41	GO10	Low NOx Portable Analyzer	20230110234320	Gas Operations	Environmental & Safety		Environment	9/1/2022	5/31/2023	$76,360	$76,360	$76,360	$0	$18,580	Completed	$0	SCG $76,360 | None $0.00	Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Share/Publish Results	The objective of this project is to investigate and experimentally determine the feasibility of an electrochemical portable analyzer test to measure low NOx and low CO emissions. The experimental outcome will include an assessment of (1) limits of detection, (2) stability, and (3) repeatability for NOx measurements less than five ppm and CO measurements less than 20 ppm. Portable emission analyzers using electrochemical cell technology have matured to provide reliable and accurate results. Recently, a PRCI project led EPA to accept new portable analyzer test methods. Portable analyzers are accurate enough to verify compliance with the low limits. Still, the need exists to push the technology and measurement even lower, which drives the limit of the technology. There is a need to understand the detection limit of portable analyzers and develop recommendations or additional provisions for ultra-low measurements, specifically in the 1.5 to 5 ppm range. The project tasks include developing a test plan and systematic testing in the laboratory and the field. The team will provide a final report detailing the limits of detection, stability, and repeatability for low NOx and CO measurements. Successful results may lead to regulators accepting the portable emissions analyzer as a valid measurement tool for verifying regulatory compliance for these ultra-low sources.	
42	GO11	Modify Pipeline Purging Program for Calculations of Methane Emissions Savings (5.17.m.2)	20200928212310	Gas Operations	Environmental & Safety		Environment	12/1/2023	12/31/2024	$17,072	$174,000	$17,072	$0		Active	$0	SCG $17,072 | OTD Members $156,928	Safety, Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to add new capabilities to GASPurge, the existing pipeline-purging software used to calculate values associated with the purging and clearing of a natural gas pipeline. The project will add a variety of features, including alternative purging and clearing processes and equipment options, feasibility break-even analysis, calculations of emissions savings, and quantification of gas not vented to the atmosphere. The updated software can support calculations for Greenhouse Gas (GHG) emissions and emissions saving reporting. Phase I of this project revamped the 1997 Gas Research Institute's Pipeline Purging Program, enabling its support by modern operating system platforms. The final Phase I deliverable was a commercially available software, GASPurge, that has been deployed and used by SoCalGas for gas purging operations. In 2023, the project team surveyed project sponsors to understand the type of equipment, methods, and processes they currently utilize for purging operations and alternatives to blow-downs. The survey feedback will be used for the next step to develop the software. SoCalGas anticipates using the updated software program when purging calculations are needed to determine safe purging parameters to improve safety and to support quantification of gas not vented to the atmosphere, a value needed for GHG emissions reporting.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
43	GO12	Odor Detection Study for Blended Hydrogen (M2021-005)	20210526154438	Gas Operations	Environmental & Safety		Safety	7/29/2021	1/31/2024	$21,835	$294,755	$21,835	$0		Active	$0	SCG $21,835.00 | NYSEARCH Members $272,920.00	Safety and Operational Efficiency	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	The objective of this project is to determine if hydrogen blends can mask common gas industry odorants. Federal regulations require odorant injection into natural gas to provide the first line of defense for consumers to detect natural gas leaks. As utilities transition to new fuels such as hydrogen, there is a lack of data and information on the compatibility of odorants in blended hydrogen with natural gas. This study will investigate several natural gas odorants for detectability and recognizability when hydrogen, at various concentrations, is present. SoCalGas will use the results of this study to adjust odorant levels in hydrogen blends to maintain the ability of consumers to detect gas leaks.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Investigating whether hydrogen could interfere with the detection and recognition of the added odorants that are critical for safe operation. 2) Determining the detectability and recognizability of some primary natural gas odorant and odorant blends in the presence of hydrogen up to 20% by volume. 3) Project results will support the hydrogen blending pilot projects. The project completed the testing portion of this project prior to Resolution ordering the use of clean renewable hydrogen.
44	GO13	Odor Detection Threshold Study - Phase II, Tasks 1 & 2 (M2016-002)	20200102215137	Gas Operations	Environmental & Safety		Safety	11/16/2019	12/31/2023	$48,100	$468,950	$48,100	$0		Completed	$0	SCG $48,100.00 | NYSEARCH Members $420,850.00	Safety	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	The objective of this project is to understand how the introduction of conditional factors of odor adaptation and odor-masking agents affect the detection and recognition thresholds of human senses. This project is Phase 2 of the natural gas odor detection threshold study and uses the odorant thresholds of human detection levels determined in Phase 1. The team studied the two phenomena in parallel, but they provided the results independently to understand each variable's effect better. This study can potentially inform decision-making regarding the odorization of natural gas. The contractor completed the odor adaptation task of the project. The study of odor-masking effects on odorants by masking agents, Limonene and Ammonia, was delayed in early 2021 due to the impacts of the COVID-19 pandemic. It established preliminary thresholds for Limonene in late 2021. In 2022, the team set the testing threshold for Ammonia. The study on Ammonia impacts will follow the Limonene study. The contractor was planning to perform the last stage of the project using volunteers to establish detection thresholds. However, this final stage was delayed since the contractor failed to meet the health protocols required by regulators. In the 3rd quarter of 2022, the contractor successfully met the required health protocols, and the last stage of the project is planned for late 2022. Once the team completes the last phase, they will publish the results in a final report. SoCalGas plans to use the study's results to evaluate if its odorant levels are adequate in its gas supply to safeguard the safety of ratepayers.	
45	~~9~~GO14	ORFEUS Obstacle Detection Technology for Horizontal Directional Drilling (5.16.k.2)	2018071855	Gas Operations	Environmental & Safety		Safety - Damage Prevention	12/1/2017	3/31/2024	$62,346	$3,786,446	$62,346	$0		Active	$0	SCG $62346 | OTD members $787,654 | PHMSA $993,970 | Others $1,942,476	Reliability, Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	• Commercialization • Share/Publish Results	Regulations require pipeline operators to mitigate geohazard and land use threats to pipeline integrity, particularly on slopes near river and stream crossings. In addition to applicable regulatory requirements, detecting and mitigating geohazard motion and ROW land use encroachment threats are primary elements of pipeline operators' damage prevention strategies and programs. This goal of this project is to develop improved methods for satellite-based tools and technologies to enhance detection of natural changes, seasonal flooding, erosional effects, channel dynamics, and ground movement affecting pipelines installed near river crossings. Successful completion of this project will identify three leading classes of satellites available in the market to support pipeline integrity programs, enhance operators' risk mitigation programs through more frequent high-resolution detection of risk factors, and right-of-way (ROW) surveillance. In 2021, the project continued with the synthetic aperture radar (SAR) data acquisition for four sites. Validation of change results against field data and high-resolution optical data is underway. A final report was drafted to summarize the results and methods for monitoring of ROWs at river crossings along with the capabilities and limitations of satellite technology.	
46	GO15	Pipeline Blending CRADA Phase 2 (Task 3, 4)	2020101615121	Gas Operations	Environmental & Safety		Safety	12/1/2023	12/31/2026	$75,000	$4,950,000	$0	$75,000	$0	Active	$0	SCG $75,000 | DOE, Others $4,875,000	Safety, Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Share/Publish Results	The Pipeline Blending CRADA Phase 2 (a HyBlend Project) is a three-year effort amongst over 20 industry partners and four National Laboratories to evaluate the costs, benefits, and environmental impacts of blending hydrogen into the natural gas grid as a decarbonization strategy. Tasks were defined for investigation. SoCalGas is participating in tasks: 3) Lifecycle Assessment and 4) Techno-Economic Analysis. The lifecycle analysis will assess hydrogen-natural gas blend leakage throughout the supply chain and study hydrogen global warming potential with the inclusion of embodied emissions for a blended gas supply chain. The techno-economic analysis will involve two efforts that build upon previous research by adding improvements and capabilities to the Pipeline Preparation Cost Analysis Tool (PPCT) and assessing hydrogen blending integration into existing regional energy systems and the impact on coupled natural gas pipeline network and power grid systems. Outcomes of this effort will help researchers quantify the impacts of each system and guide best practice development on how to effectively implement hydrogen-natural gas blending to reduce overall energy system emissions and enhance energy system reliability. SoCalGas will use the results of this research to support the development of its blending standard and to understand the economic and technical aspects of efficient and effective implementation of hydrogen blending.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Supporting a on Life-Cycle Assessment (LCA) and Techno-Economic Analysis (TEA) that provides a model with a higher lever overview of the impact of hydrogen on all pipeline assets: transmission, distribution, and underground storage. 2) TEA and LCA results will support implementation decisions for the use of hydrogen within natural gas pipelines. 3) The hydrogen blending pilot will collect the data to use as an input for the TEA and LCA for the distribution system that will help improve the models. This project scope does not include testing using hydrogen.
47	GO16	Plastic Gas Pipe Damage Assessment due to high pressure water jets and cross bores (5.23.g)	2023011724210	Gas Operations	Environmental & Safety		Safety - Damage Prevention	12/14/2022	9/30/2024	$24,038	$125,000	$24,038	$0		Active	$0	SCG $24,038 | OTD Members $100,962	Reliability, Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Early Stage (TRL 1-3)	Deployment of Results; Share/Publish Results	The objective of this project is to evaluate the effect of high-pressure (HP) water nozzles used in the sewer cleaning industry on polyethylene (PE) pipe materials to determine the impact on PE cross-bores. The team will work with industry leaders to identify multiple water nozzles used in the sewer industry, construct a testing rig, and develop guidelines to close the knowledge gap between safe and unsafe water jetting on cross-bores. Cross-bores are when PE pipe is inadvertently installed into sewers or sewer laterals. HP sewer pipe cleaning jets can create holes or damage PE cross-bores during sewer cleaning, resulting in gas leaks or more serious incidents. Currently, no standard or guideline limits the pressure and performance of sewer cleaning nozzles so they do not damage PE cross-bores. The deliverables for this project will be a final report detailing the results of the HP nozzle testing and a set of guidelines written by the project team for sewer cleaning and the use of HP water nozzles around plastic cross-bores. The team will standardize these guidelines and the test procedure so that new sewer cleaning nozzles can be tested and evaluated. The standards could benefit SoCalGas by reducing risk, improving safety and pipeline integrity, reducing costs associated with damage and resulting incidents, and informing SoCalGas' Integrity Management Plan.	
48	~~10~~GO17	Reciprocating Engine Exhaust Methane Slip Reduction (GHG SRP CPS-17-08)	20210408135911	Gas Operations	Environmental & Safety		Environment	3/16/2021	12/31/2024 ~~3/16/2023~~	$22,046	$454,300	~~12708~~ 22,046	~~9338~~ 0		Active	$0	SCG $22,046 | PRCI Members $432,254	Environmental: Improved Air Quality and Environmental: Improved Air Quality	Early Stage (TRL 1-3)	• Further Technology Development/Prototype	This Pipeline Research Council International Strategic Research Priority project is a multi-year effort to reduce criteria pollutants and greenhouse gas (GHG) emissions from legacy compressor engines. The project will investigate the effects of quenching the main chamber, nitrogen formation mechanism and pre-combustion chamber size, and an early ignition and seeding radicals in the main chamber. The initial planned literature review has been completed. The team is currently tuning the computational fluid dynamic model that will be used for pre-combustion chamber design and prototyping. Next steps include laboratory and field evaluation of the prototype. The results from this project could be used to retrofit legacy engines and changes in controls, which could lead to reductions in criteria and GHG emissions. Retrofitting legacy engines to reduce GHG and criteria pollutants is less expensive than replacing them. This option benefits ratepayers with a much more cost-effective alternative in combating climate change and improving air quality.	
49	GO18	Remote Gas Sensing For First Responders - Phase 4 (7.15.b.4)	20190919162242	Gas Operations	Environmental & Safety		Safety	9/1/2019	12/1/2024	$27,000	$358,000	$27,000	$0		Active	$0	SCG $27,000.00 | OTD Members $331,000.00	Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing;	During natural gas leak investigations, first responders need the means to assess gas concentration outdoors, in manholes, and within buildings. Knowing the gas concentration remotely at multiple locations will save time and improve safety. This project aims to commercialize two instruments explored in previous phases of this project; these are the "First Responder" and the "Un-attended Methane Monitor" devices. In earlier phases of the project, a methane detection system prototype was developed to enable a leak investigator to remotely monitor methane levels at multiple points within a site under investigation. There are two objectives for Phase 4. The first is to develop pre-commercial units that can be tested by utility members. The second is to develop a wireless communication system to allow a leak investigator to monitor methane levels at multiple points remotely. In 2022, work started on design reviews for the mechanical assemblies. Initial integration of the project's mechanical, electrical, firmware and software components was completed as well as the first functioning prototype using silicone molded parts. The First Responder Mesh Network application has been developed as the GIZMO (Gas Investigation Zone Monitor). The prototype will be available for beta testing soon. Once the development of GIZMO is complete, further development of the Un-attended Methane Sensor will begin. Once this project is finished, SoCalGas will consider evaluating the technology for use in the field.	
50	~~11~~GO19	Smart Shutoff Technology for Commercial and Residential Buildings (5.20.k)(CEC GFO-19-502, group 2)	20200109154639	Gas Operations	Environmental & Safety		Safety	8/4/2020	1/31/2024 ~~8/4/2023~~	$25,019	$1,200,000	$25,019	$0	$4,269	Active	$0	SCG $25,019 | OTD Members $118,981 | CEC $1,056,000	Reliability and Safety	Late Stage (TRL 7-9)	• New Research Project to Advance TRL Level • Commercialization	This project is funded by the California Energy Commission (CEC) to improve the safety and integrity of natural gas infrastructure. The objective is to provide the natural gas industry with the necessary hardware and software components to create a full-solution, smart shut-off system capable of detecting and terminating gas flow in response to a hazardous incident such as fire, flood, or gas leak inside a residential or commercial structure. Deployment of smart shut-off systems can provide the localized detection and mitigation needed to prevent hazardous events from becoming excessively dangerous and costly. This project will demonstrate and validate the technologies needed to implement a smart shut-off system, as well as identify any gaps or barriers that need to be addressed prior to commercialization. In 2021 the project scope was modified to better understand the deployment of a Low Power Wide Area Network (LPWAN) at scale after identifying knowledge gaps in the communication methodology. In 2021, a Site Readiness Report was prepared along with a draft Hardware Validation Report. Field demonstrations for the Smart Safety Shutoff System are scheduled to begin in 2022.	
51	~~12~~	~~Stanford Natural Gas Initiative Program~~	~~160101318~~	~~Gas Operations~~	~~Environmental & Safety~~		~~Environment~~	~~1/1/2019~~	~~12/31/2023~~ ~~12/31/2022~~	~~$225,000~~	~~$1,795,000~~	~~$225,000~~	~~$0~~	~~-~~	~~Completed in 2022~~	$0	~~SCG $225,000 | NGI Members $1,570,000~~	~~Safety, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality~~	~~Mulitple - Program supports various projects.~~	~~• Mulitple - Program supports various projects.~~	~~The Stanford Natural Gas Initiative (NGI) is a collaboration of more than 40 research groups at Stanford University drawn from engineering, science, policy, geopolitical, and business disciplines that works with a consortium of industry partners and other external stakeholders to generate the knowledge needed to use natural gas to its greatest social, economic, and environmental benefit. It focuses on creating innovative technologies for natural gas production from unconventional sources, alternatives to hydraulic fracking, and offshore methane hydrates. NGI organizes its research portfolio into seven focus areas and operates a seed grant program to encourage new research on natural gas by Stanford researchers. It provides strategic funding to support important research in other areas related to natural gas and energy. In 2021, NGI published three natural gas briefs, two white papers, nine research papers and conducted multiple seminars, dialogues, meetings, webinars, and workshops.~~	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
52	GO20	Subsurface Multi-Utility Asset Location Detection (5.20.a)	20191213153110	Gas Operations	Environmental & Safety		Safety - Damage Prevention	12/1/2019	9/30/2024	$29,715	$2,094,494	$29,715	$0		Active	$0	SCG $29,715.00 | OTD Members $175,668.00 | PHMSA $1,028,122.00 | Others $860,989.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The goal of this project is to conduct field trials on and subsequently commercialize a continuously locatable, on-pipe, electronic marking system using discrete radio frequency identification (RFID) to locate polyethylene (PE) pipes. PE pipes are not as locatable as their metal counterparts, and locating accuracy could be enhanced by a high-accuracy GPS locating system. The accurate location of buried PE pipe reduces the risk of third-party excavation damage. Ideally, the markers could be integrated into the pipe during the manufacturing process. Operators could use the system to document the location of subsurface plastic pipes, provide accurate GPS coordinates for pipes and points of interest, and assign a quality score to the location data that is then transferred to an operator's GIS. In 2022, the team continued working on optimizing the electronic pipe markers and enhancing the attachment methods for the markers to the PE pipe. The project team disagreed on whether electrofused or taped markers would be utilized. The methodology may differ by pipe size. Adding to the project delay was a change in the members of the project team which resulted in a reassessment of the path forward. PHMSA has granted an extension to the project end date.	
53	~~13~~GO21	Tracking Software Development for Pipeline Safety Management System (8.21.h)	20210824142625	Gas Operations	Environmental & Safety		Safety	11/24/2021	5/24/2023	$21,464	$220,000	$21,464	$0		Completed	$0	SCG $21,464 | OTD Members $198,536	Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	• Field Demonstration/Validation Testing	The objective of this project is to develop tracking software for Pipeline Safety Management Systems (PSMS) based on the American Petroleum Institute's (API) 1173 standard This standard addresses the program development and program performance assessments. The tracking software will develop a Key Performance indicator (KPI) and a scoring system to assist managers in evaluating the performance of their PSMS program. The software will aid in benchmarking PSMS performance for the continuous improvement process required under API 1173. With the software, utilities will continue to improve their PSMS to benefit ratepayers with a safer and more reliable service. .	
54	GO22	Validation of Next Generation Predictive Emissions Monitoring System for Gas Turbines (CPS-2-03)	20221007183148	Gas Operations	Environmental & Safety		Environment	11/1/2022	4/30/2024	$20,000	$65,000	$9,819	$10,181	$4,968	Active	$0	SCG $20,000.00 | PRCI Members $45,000.00	Reliability, Operational Efficiency, Improved Affordability, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Share/Publish Results	The project objective is to validate the next generation of predictive emission monitoring systems (PEMS) for gas turbines developed by Siemens Energy. The Siemens PEMS is a turbine operating parameter-based system for predicting turbine emissions. This approach is less costly than continuous emission monitoring systems, which have high capital investment and operating costs. A PEMS could also be used as a diagnostic tool for evaluating turbine performance and optimizing downstream control equipment to reduce operating costs and emissions. SoCalGas will partner with PRCI and Siemens Energy by using the turbine located at the SoCalGas Blythe facility for the PEMS validation. SoCalGas and Siemens Energy will gather operating data from actual operating conditions. Siemens will then use the data to evaluate its PEMS model. The final deliverable will be a report on the results of the PEMS validation. The project results could lead to lower environmental compliance costs, a new diagnostic tool for evaluating turbine performance, and optimization of control equipment operations for the utility industry and SoCalGas. SoCalGas will assess the outcome of this project to see if the PEMS will benefit its operations.	
55	GO23	Virtual Reality (VR) Training - Emergency Response Situations (5.18.t.2&3)	20191107214525	Gas Operations	Environmental & Safety		Safety	11/1/2019	6/23/2023	$80,000	$806,000	$80,000	$0		Completed	$0	SCG $80,000.00 | OTD Members $726,000.00	Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Technology & Knowledge Transfer/Training	This GTI Energy project intends to develop a Virtual Reality (VR) content library and delivery system that utilities can use to assist in training their personnel on operation and maintenance procedures. This project will develop and use realistic, interactive, and immersive VR training modules that provide utilities with several operational advantages and guidance on deploying them. The project team will evaluate current VR technology to determine if new developments can enhance the VR training experience. SoCalGas using VR modules will improve learner retention, enhance the consistency of training delivered, allow operations to conduct training on demand, increase the number of real-life training scenarios available for trainees to experience, and reduce the risk of injury to trainees. The project team developed nine training modules, and SoCalGas evaluated this technology in 2022. GTI Energy is developing and re-developing the training modules on a new provider platform with an estimated completion date of March 31, 2023. GTI Energy created a draft implementation plan for SoCalGas in 2022 and will present the new modules, platform, and finalized implementation plan to the SoCalGas Training Department in early 2023. SoCalGas intends to implement this VR technology into its Training program.	
56	~~14~~GO24	Work Zone Intrusion Detection and Warning System (8.22.g)	2022010601739	Gas Operations	Environmental & Safety		Safety	11/19/2021	1~~2~~4/~~13~~28/2023	$9,333	$140,000	~~8000~~ $9,333	~~1333~~ 0		Completed	$0	SCG $9,333 | OTD Members $130,667	Safety	Mid Stage (TRL 4-6)	• Deployment of Results • Share/Publish Results	The objective of this project is to perform market analysis and testing of Work Zone Intrusion Alarm (WZIA) technologies. Deliverables will include a Cost Benefit Analysis detailing features and pricing of the evaluated solutions and recommendations based on the various work zone scenarios that field crews may encounter. The goal is to improve the safety of employees and contractors working in situations where there is a possibility of work zone intrusion by unauthorized vehicles or pedestrians entering the work zone. Research suggests that implementing WZIA technology aids in the prevention of work zone injuries or fatalities. There is a broad range of functionality and cost between the various available technology solutions, but there is not a well-established marketplace, so further research is needed. The project is expected to kickoff at the early 2022. .	
57	~~15~~GO25	3D Visualization Software for Mapping Underground Pipelines and Improving Pipeline Asset Management (8.20.m)(CEC GFO-19-502, group 4)	202001091765	Gas Operations	Operations Technology		Mapping and Locating Technologies	6/30/2020	~~7/31/2023~~ 3/29/2024	$89,349	$2,088,785	$89,349	$0		Active	$0	SCG $89,349 | OTD Members $261,000 | CEC (GFO-19-502) $1,738,436	Reliability and Safety	Mid Stage (TRL 4-6)	• New Research Project to Advance TRL Level • Further Technology Development/Prototype • Commercialization	A significant amount of third-party damage to buried infrastructure is associated with inaccurate or insufficient locating practices. Knowing the location of the buried infrastructure can significantly aid in mitigating these risks and prevent damages. In this CEC co-funded project, GTI will develop 3D visualization software for mapping underground pipelines and improving pipeline asset management. To achieve this, several existing and proven technologies will be combined to create the Locate Technology Platform (LTP). This solution creates a set of business process models that an organization may implement to improve the three-dimensional geospatial accuracy of existing GIS data in both the horizontal and vertical dimensional directions. This platform assists the field users in visualizing infrastructure location data from a variety of viewpoints. Once the LTP is completed, it will be validated in a field demonstration. In 2021, software development began and data fields to be collected were identified. Efforts to create an in-office web application that would display GIS features in a 2D and 3D format from an accessible website are in process. .	
58	GO26	Advanced Locating Technology with Exodigo (8.22.p)	20220823153734	Gas Operations	Operations Technology		Mapping and Locating Technologies	10/18/2022	3/31/2024	$77,648	$220,000	$77,648	$0		Active	$0	SCG $77,648.00 | OTD Members $142,352.00	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Deployment of Results	The objective of this project is to evaluate the capabilities and performance of a non-intrusive subsurface mapping platform that uses multiple sensors and artificial intelligence to provide a digital geolocated representation of underground assets. The ability to map and locate existing underground infrastructure with increased accuracy and completeness of pipeline data supports damage prevention for gas utilities. The project scope includes performing a baseline evaluation of the technology at GTI Energy's pipe farm and a field demonstration at a sponsor location. The team will perform a comparative analysis between this technology and other locating technologies previously evaluated on the known underground pipe system at GTI Energy. The team will deliver a final report which will provide the analysis and comparative results and identify potential use cases within the natural gas industry. If this technology demonstration is successful, it could give the utilities another option for locating or mapping underground assets. SoCalGas may pursue its own field demonstration and evaluation after reviewing the project deliverables.	
59	~~16~~GO27	Alternative Steel and Composite Material and Liquid Pipeline Systems (5.22.f)	20220112185929	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	12/14/2021	12/31/2024	~~12706~~ 11,019	$1,008,320	~~8000~~ $11,019	~~4706~~ 0		Active	$0	SCG $12,706 | OTD Members $135,000 | PHMSA $873,320	Safety and Operational Efficiency	Mid Stage (TRL 4-6)	• Field Demonstration/Validation Testing • Modification to Regulatory; Policy & Standards	The objective of this project is to establish a framework and corresponding requirements for the installation, inspection, and integrity management of alternative-steel and composite systems in natural gas pipelines. The study addresses: (1) material testing, (2) construction requirements, (3) damage and assessment of defects, (4) degradation of the pipe material, and (5) inspection and maintenance activities. The project is designed to map the requirements under 49 Code of Federal Regulations (CFR) Part 192. The goal is to identify and address the gaps in implementing a qualification process for non-steel and alternate-steel composites similar to the ones currently used for steel pipes. Pipeline Hazardous Materials Safety Administration held their kick-off meeting in November 2021 where they started forming the Technical Advisory Panel. The next steps are to hold an Operations Technology Development kick-off meeting and to begin evaluating material properties and testing procedures to determine how they might be modified to be applicable for the full range of modern materials. .	
60	GO28	Continuation of Single-Path Ultrasonic Meter Long Term Performance Testing & Monitoring (5.20.e.2)	20201222164438	Gas Operations	Operations Technology		Measurement & Regulation Operations Technologies	12/2/2020	12/29/2023	$5,375	$129,000	$5,375	$0		Completed	$0	SCG $5,375.00 | OTD Members $123,625.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Field Demonstration/Validation Testing; Share/Publish Results	The objective of this project is to build upon research identified by Operations Technology Development (OTD) Project 5.19.h: Single Path Ultrasonic Meter (USM) Performance Testing (Phase 1). The project team will add a smart diaphragm residential gas meter (DRGM) to the earlier accuracy evaluation. An interim report provided performance testing results evaluating the effectiveness of the smart gas meter shut-off valve, enabling 1) comparison of the local distribution company's DRGM metrology results with the two ultrasonic meters (USMs) tested in Phase I and 2) evaluation of the communication capabilities of the three meters from both Phase 1 and this project. In this project, the team is evaluating the effectiveness of the smart shut-off valve and communication capabilities of all three meters. In 2021, the project identified the locating and mounting mechanisms, completed the setup of simulated power for replicating different battery capacity levels, and completed accuracy tests on all three meters for an outdoor accelerated life test. In 2022, all testing for the smart DRGM was completed, while testing for the USMs is ongoing. The next steps are to complete the USM testing and draft the final report. SoCalGas could use this information to supplement its evaluations of new metering technology for ultrasonic meters.	
61	GO29	Data Logger Evaluation Project - Phase II	20210702163440	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	6/15/2021	12/31/2024	$320,000	$320,000	$42,735	$277,265	$42,735	Active	$0	SCG $320,000.00 | None $0.00	Reliability, Safety, and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to evaluate a commercially available data logging technology for collecting data associated with the fusion joint process. Thermoplastic pipeline joints are produced in the field using a pipeline fusion processes (e.g., heat and pressure). High-quality joints are critical to the integrity (e.g., safety and reliability) of natural gas pipeline facilities. There is presently no automated data collection process for field fusion operations. This process has significant potential for errors and is not an efficient means of integrating the fusion data into company systems, thus encumbering review and analysis. Furthermore, in cases of failure, the fusion data is not readily available for review to aid the investigative process. During the project's first phase, the team performed a proof-of-concept evaluation for a commercially available data logger. In phase II, the team is researching the process of data collection, storage, and integration into company systems. It is anticipated that the collected fusion data will allow real-time evaluation of fusion parameters such that fusion joints are produced with consistent quality before being placed into service. In 2022, the project team worked with a data logger manufacturer and a SoCalGas IT team to identify software developments needed for data integration into Company data management systems. Additionally, the team has worked on resolving technical issues with the data logger, continued to collect fusion data in the field, and conducted training for welding instructors. Moreover, the project team worked on preparing a plan for the next steps of this project. A final report describing the work performed, and the necessary software developments will be provided.	
62	~~17~~GO30	Enhanced Locating Technologies for Underground Pipelines with Better Accuracy (8.20.l)(CEC GFO-19-502, group 3)	20200109162122	Gas Operations	Operations Technology		Mapping and Locating Technologies	11/4/2020	~~11/30/2023~~ 3/31/2024	$26,768	$2,222,903	$26,768	$0		Active	$0	SCG $26,768 | OTD Members $207,146 | CEC $1,821,631 | Other Technology Providers $167,358	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	• Further Technology Development/Prototype • Commercialization • Share/Publish Results	The objective of this CEC-cofunded project is to improve the safety and integrity of underground natural gas pipelines by increasing the accuracy and availability of horizontal and vertical pipeline location information. The approach is based on enhancing and adapting aboveground, large standoff, 3D electromagnetic detection technology to locate buried pipelines. It will supplement the technology with an in-pipe mechanism to focus on congested areas and plastic materials. SoCalGas will focus on transmission infrastructure while PG&E will focus on infrastructure in congested urban areas. Improved tools are intended to provide access to three-dimensional data in near-real time, and the combined solution is anticipated to apply to most in-field conditions including varying pipeline material, depth, and surface cover. In 2021, gathering and analyzing data from the GTI test site with buried pipes continued. Planning of the 2022 field demonstration at SoCalGas started and a test plan was developed. .	

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1	**No.**	**Project Title**	**Project Number**	**Program**	**Sub-program**	**2022 approved new sub-program**	**Research Area**	**Start Date**	**Anticipated End Date**	**SCG Budget**	**Total Project Cost**	**Amount Already Spent**	**Amount Still to be Spent**	**Actual Incurred Costs Jan-Nov '23**	**Status**	**Estimated Incurred Costs Jan-Nov '23**	**Co-funders & Co-funding contribution**	**Project Benefits**	**Technology Readiness Level**	**Anticipated Next Steps at End of Project**	**Project Description**	**Hydrogen Blending Projects**
63	GO31	Enhancements to ASTM F2897 Encoding Standard for Gas Distribution Components (5.22.v)	20220606163551	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	6/17/2022	12/1/2023	$32,827	$151,000	$32,827	$0		Completed	$0	SCG $32,827.00 | OTD Members $118,173.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards	The objective of this project is to review and affirm the underlying mathematical model and requirements within the American Society for Testing and Materials (ASTM) F2897 and to make targeted enhancements to its completeness and efficacy. In addition, a goal is to develop an implementation guide within the ASTM standard to aid the proper application and use of the system. After nearly a decade of existence and use, there is a need to review and enhance ASTM F2897 "Standard Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)." Polyethylene (PE) pipe and tubing manufacturers utilize this standard to incorporate a 16-digit barcode on the materials they produce for tracking and traceability purposes. The project team will review the standard and verify that all the gaps are addressed and that the standard provides the necessary information for all types of materials for successfully applying barcodes. This project is important as SoCalGas will eventually implement barcode scanning of materials in the field for improved tracking and tractability. The final deliverable will be the revised ASTM F2897 standard.	
64	~~18~~GO32	Evaluation of Micro-Thermal Gas Metering Technology (5.22.d)	202201060215	Gas Operations	Operations Technology		O&M Technologies	11/19/2021	~~9/30/2023~~ 11/30/2023	$13,200	$132,000	$1,003,200	~~3200~~ 0		Completed	$0	SCG $13,200 | OTD Members $118,800	Reliability and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	• Field Demonstration/Validation Testing • Share/Publish Results	The objective of this project is to evaluate the accuracy and overall performance of micro-thermal gas metering modules while measuring hydrogen-blended natural gas and biomethane gas volumes. The microthermal gas meter module consists of a Micro-electromechanical Systems (MEMS) -based calorimetric microsensor. The MEMS measures the flow of natural gas using the thermal measurement principle. The sensor element is located on a membrane and consists of a micro-heater and upstream and downstream temperature sensors. The temperature distribution characteristics during gas flow are used to determine the gas velocity and the gas volume. It is integrated with signal conditioning electronics including memory for calibration data. Gas utilities are increasingly considering the proposition of transporting fuels of varying constituents. This includes low-carbon-based fuels such as hydrogen-blended natural gas and renewable natural gas. The source of these fuels varies and so does the gas compositions. A reliable metering technology that can be easily calibrated to varying gas compositions provides an additional layer of operational flexibility to gas utilities and enables the diversification of gas quality in the network. The project is expected to kickoff at the beginning of the second quarter of 2022.	Hydrogen-Blending Project The project was completed prior to Resolution.
65	GO33	GNSS Consortium (5.7.p)	202301111022	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	12/14/2022	12/21/2023	$15,000	$245,000	$15,000	$0		Completed	$0	SCG $15,000.00 | OTD Members $255,000.00	Operational Efficiency and Improved Affordability	Late Stage (TRL 7-9)	Technology & Knowledge Transfer/Training	The Global Navigation Satellite System (GNSS) Consortium intends to facilitate knowledge and information sharing on rapidly developing GNSS technology and to determine how to apply this information to daily utility operations. The project team will accomplish this through technology evaluations and integrations, workshops, pilot projects, demonstrations, best practices and standards, and general information sharing. The focus on technology evaluation helps reduce the cost and complexity of deploying GNSS for routine utility construction operations and maintenance activities. High-accuracy GNSS data collection is essential to a utility's geospatial data management and Geographic Information Systems (GIS) integrity. The GNSS Consortium was initiated in 2017. In 2023, GTI Energy will continue to perform demonstrations and inform the project sponsors about the latest innovations and research in the geospatial technology industry. The project team will upload all deliverables to the enhanced web-based library, including technology evaluation reports, multimedia materials, training documentation, a close-out webinar, annual workshop materials, and a yearly GTI Energy GIS Week presentation. By staying abreast of current and cutting-edge advanced GNSS technology, SoCalGas will be equipped to make informed investment decisions related to geospatial technology and benefit from enhanced operational efficiencies, regulatory compliance, improved quality of field-collected data, and improved system integrity. SoCalGas intends to disseminate the research to its internal stakeholders for implementation in daily operations. SoCalGas hopes to identify low-cost alternatives for geospatial tracking of high-volume distribution pipeline components.	
66	GO34	Guidance for H2/NG Blending Equipment Installation and Operations (5.23.p)	2023090822515	Gas Operations	Operations Technology		O&M Technologies	12/1/2023	5/31/2024	$23,349	$179,000	$0	$23,349		Active	$0	SCG $23,349 | OTD Members $155,651	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Deployment of Results; Share/Publish Results	The project objective is to shape and develop safety practices for blending hydrogen into natural gas pipeline systems by identifying the requirements, steps, and procedures involved. The project will address this through 1) a multi-disciplinary team conducting experimental work, 2) model development derived from the experiments, 3) validation of the analyses through component-level testing, and 4) two case studies and a techno-economic analysis. This project should help understand the condition of existing pipeline assets when introducing hydrogen blends, quantify potential safety risks, and update integrity management practices for better risk management. This project will deliver a systemwide quantitative risk analysis model that can be used to improve the safety protocols of the studied cases and provide recommendations to better prepare gas utilities and facility operators for hydrogen blending at larger scales. SoCalGas intends to use this research in cooperation with other California Investor-Owned Utilities by incorporating the findings into a preliminary statewide hydrogen blending standard that the California Public Utilities Commission will regulate. If the project proves successful, SoCalGas can use the results in its pipeline integrity risk assessment program to determine safe pipeline and operating parameters for introducing hydrogen into natural gas infrastructure.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Providing results prior to the approval of the hydrogen blending pilot and support hydrogen blending pilot related projects. 2) This project will provide procedures and recommended practices to guide SoCalGas in planning and executing our hydrogen blending demonstartion projects. 3) The financial analysis will aid in understanding the investments required for hydrogen blending pilots and future natural gas system implementation. This project scope does not include testing using
67	GO35	In-Situ Ultrasonic Gas Flow Meter Flow Verification (MEAS-6-17C)	2023081402012	Gas Operations	Operations Technology		O&M Technologies	12/1/2023	6/30/2025	$14,465	$265,500	$0	$14,465		Active	$0	SCG $14,465.00 | PRCI Members $251,035.00	Operational Efficiency and Improved Affordability and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop and test a prototype for applying the gas tracer ultrasonic meter (USM) verification method from previous research efforts in a field setting. Previous research efforts (Pipeline Research Council International projects: MEAS-6-17, MEAS-6-17A, and MEAS-6-17B) tested the proof of concept for an in-situ gas tracer verification method for USMs in natural gas service using helium and achieved an average error of ±0.05%. A prototype for verifying USM field performance without service interruption would provide cost savings by identifying issues sooner and more quickly, and from not having to remove the USM from service for flow verification. The project team is developing a functioning prototype to deploy the gas tracer method of USM verification, will provide a final report that includes field data that illustrates the performance of the method and prototype, and will then propose this method to be used as a recommended practice within American Gas Association's published Report No. 9 (AGA 9), Measurement of Gas by Multipath Ultrasonic Meters. If the prototype and methodology are successful and adopted by AGA 9, SoCalGas would utilize this prototype verification method for calibration use for in-situ USMs if it is available as a service offering.	
68	GO36	Market Study and Technology Assessment of a High Concentration Hydrogen Leak Detector (T-792)	2023010531032	Gas Operations	Operations Technology		O&M Technologies	11/23/2022	10/31/2023	$6,940	$71,127	$6,940	$0		Completed	$0	SCG $6,940.00 | NYSEARCH Members $64,187.00	Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Further Technology Development/Prototype	The objective of this project is to perform a state-of-the-art study to identify technologies for walking and mobile leak survey instruments to detect up to 100% hydrogen. Molecules of hydrogen are smaller than those of methane, and at higher blended percentages of hydrogen (20% - 100%), hydrogen could leak and not be detected using existing methane and hydrogen sensors. These higher hydrogen percentages may require specific leak detection technologies or existing equipment retrofitting. The natural gas industry needs research to identify the parameters for choosing the correct leak detection device for gas blends containing over 20% hydrogen. The project team will deliver a shortlist of potential technologies for walking and mobile leak detection applications and a roadmap for technology evaluation and development. This project could benefit SoCalGas by providing a shorter-term solution for hydrogen leak detection for gas blends containing over 20% hydrogen, which could enhance safety, reduce emissions, and save time and capital in the transition to utilizing these blends. SoCalGas could take the results to determine if developing a leak detector for gas blends containing over 20% hydrogen is warranted and if this detector could be made commercially available.	Hydrogen-Blending Project The project was completed prior to Resolution.
69	GO37	Screening Remote Flow Monitoring and Control (5.22.u)	2017092276	Gas Operations	Operations Technology		O&M Technologies	10/31/2022	3/30/2024	$42,824	$130,000	$42,824	$0		Active	$0	SCG $42,824.00 | OTD Members $87,176.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Share/Publish Results; Technology & Knowledge Transfer/Training	With the increasing amount of renewable natural gas (RNG) in the distribution network, Distribution System Operators now have an additional role in managing the volume of gas from multiple injection sources. As the industry transitions, smart technologies could aid in the remote operation and flow management of the natural gas infrastructure. The objective of this project is to perform a review and screening of the latest advancements in smart and remote equipment applications for distribution systems. The project scope includes 1) identifying operator requirements and needs, 2) performing a market study to review the latest remote equipment and related communication systems, and 3) determining which products are in development and which are commercialized. The remote equipment includes on/off valves, regulation valves, pressure reduction gas stations, and backflow compressors. The project team will deliver a final report at the end of the research to include the industry needs and market product gaps for remote flow monitoring technologies. Future District Regulator Station designs will consist of proven remote monitoring and control equipment that will further enhance the operational safety and flexibility of the system and allow for RNG capacity.	
70	GO38	Targeted Hydrogen Blending in Gas Infrastructure for Decarbonization (GFO-21-507)	2022111424816	Gas Operations	Operations Technology		O&M Technologies	12/9/2022	3/31/2026	$15,000	$7,216,729	$6,726	$8,274	$6,726	Active	$0	SCG $15,000.00 | CEC $5,658,000.00| Others $1,543,729	Reliability, Safety, and Environmental: Reduced GHG Emissions	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Modification to Regulatory Standards & Policy; Deployment of Results	The project objective is to shape and develop safety practices for blending hydrogen into natural gas pipeline systems by identifying the requirements, steps, and procedures involved. The project will address this through 1) a multi-disciplinary team conducting experimental work, 2) model development derived from the experiments, 3) validation of the analyses through component-level testing, and 4) two case studies and a techno-economic analysis. This project should help understand the condition of existing pipeline assets when introducing hydrogen blends, quantify potential safety risks, and update integrity management practices for better risk management. This project will deliver a systemwide quantitative risk analysis model that can be used to improve the safety protocols of the studied cases and provide recommendations to better prepare gas utilities and facility operators for hydrogen blending at larger scales. SoCalGas intends to use this research in cooperation with other California Investor-Owned Utilities by incorporating the findings into a preliminary statewide hydrogen blending standard that the California Public Utilities Commission will regulate. If the project proves successful, SoCalGas can use the results in its pipeline integrity risk assessment program to determine safe pipeline and operating parameters for introducing hydrogen into natural gas infrastructure.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Identifying the requirements, steps, and procedures involved with blending hydrogen into natural gas pipelines for industrial applications, whereas our demonstration projects will evaluate residential applications. 2) This project examined hydrogen blending impacts on component level, such as turbines and compressors, and on system level for industrial and power generation applications, whereas our demonstration projects will evaluate residential applications. This is not a live blending project and will analyze impacts downstream of the customer meter. 3) Project results will support the baseline assessment for the use of hydrogen within natural gas pipelines including the hydrogen blending pilots. This project scope does not include testing using hydrogen.
71	GO39	Technology Testing Assessment Facilities (AMI Smart Metering)	20200114225427	Gas Operations	Operations Technology		Pipeline Construction, Operations and Repair Technologies	1/1/2019	12/29/2023	$124,300	$124,300	$124,300	$0	$1,810	Completed	$0	SCG $124,300.00 | None $0.00	Reliability, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Feasibility/Proof-of-Concept; Further Technology Development/Prototype; Technology & Knowledge Transfer/Training	This project aims to evaluate new technologies, tools, and equipment at the SoCalGas Gas Meter Test Rack or Situation City. A frequent challenge faced by utilities is the need to find tools or technologies that increase safety, lower operation and maintenance costs, improve accuracy, and replace existing obsolete equipment and tools. SoCalGas has constructed its test facilities to simulate portions of the company's operating system. This approach enables the evaluation of new tools or technologies without impacting system operations or customers. Technology performance that passes the minimum requirements may be approved and deployed in company operations. Currently, the Measurement Technology Group is evaluating the functionality and reliability of a residential ultrasonic gas meter and an advanced metering infrastructure (AMI) network. This proof-of-concept pilot project leverages a new AMI network to receive real-time data from gas meters, multi-variable sensors, cathodic protection test stations and supports an integrated distribution automation system. To date, meters were tested and then returned to the manufacturer so that they could address concerns of inaccuracy. In 2022, the manufacturer delivered updated meters that addressed the previous measurement and communication issues for the accelerated life accuracy testing. The meters passed ANSI B109 testing and are currently installed on the test rack, with testing scheduled to be completed in early 2023.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
72	GO40	Ultrasonic Meter Demonstration	20240104184237	Gas Operations	Operations Technology		O&M Technologies	12/1/2023	12/31/2025	$750,000	$750,000	$0	$750,000	$0	Active	$0	SCG $750,000.00	Reliability, Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing; Commercialization; Deployment of Results	The objective of this project is to demonstrate and pilot ultrasonic residential meters to evaluate their functionality and to develop a data collection and analysis process. This self-diagnostic meter contains an accelerometer with a valve at the gas inlet and uses the speed of sound to measure gas flow, records gas pressure, and temperature. New safety analytic data for meter pressure, temperature, seismic activity, and flow will enable greater proactive safety outreach and response. The project has completed the necessary meter testing criteria to allow the meter to be deployed to support the use of ultrasonic meters for new business and planned meter changes. Each meter will have a cellular line to transmit the meter's data to a cloud-based system and can send a remote valve closure command with an alarm for gas temperature and pressure readings outside the set range. SoCalGas anticipates the research findings on the new safety analytic data for meter pressure, temperature, seismic activity, and flow will enable proactive safety outreach and response.	
73	GO41	A Framework for Improved Geohazard Monitoring, Data Integration, and Information Fusion at Scale (OTD 5.24.i)	2024011022308	Gas Operations	System Design & Materials		Geohazard Design	12/1/2023	11/30/2026	$4,929	$819,252	$0	$4,929		Active	$0	SCG $4,929 | OTD Members $58,624, PHMSA $399,252, Others $356,447	Reliability, Safety	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to develop a framework and architecture for geohazard data that could be integrated into models for monitoring and forecasting geohazard risks. This Pipeline and Hazardous Material Safety Administration co-funded project will combine government and industry monitoring data, and geohazard and pipeline inspection, into the design of the framework to be used in geohazard models. The project team will standardize the data so it can be streamlined and integrated into a network of different models for geohazard monitoring and forecasting, thus saving time and processing. Furthermore, where possible, real-time data will be standardized for use in models. The approach will improve geohazard monitoring and forecasting to mitigate geohazard risks and improve pipeline safety. This is the first stage in the development of the type of system SoCalGas wants to implement in the future to monitor, forecast, and mitigate geohazard risks. If this project is successful, it will benefit the ratepayers as it will provide utilities a more efficient and holistic way to monitor, in real time, any threats to our system and may give us early warning detection to take preventative measures in sufficient time.	
74	GO42	Action Limits for RNG Specifications (7.23.k)	20221123205646	Gas Operations	System Design & Materials		Gas Composition And Quality	12/1/2022	6/30/2025	$543,445	$1,256,000	$543,445	$0		Active	$0	SCG $543,445.00 | OTD Members $712,555.00	Reliability and Safety	Early Stage (TRL 1-3)	Share/Publish Results	The objective of this project is to monitor available literature and gather operational data to support renewable natural gas (RNG) action limits for trace constituents. In 2020, the California Public Utilities Commission (CPUC) approved the Standard Renewable Gas Interconnection Agreement, which included a requirement to provide action-level specifications for ammonia, mercury, and siloxanes. Previous research determined that additional studies are needed to assess the effects of trace constituents on the natural gas pipeline infrastructure and end-user equipment, particularly mercury, on non-cryogenic end-user equipment. The project team will refresh the literature review for mercury studies and develop an experimental plan for laboratory testing at Southwest Research Institute for a future research project. The California utilities can benefit from this research since it fulfills a CPUC regulatory directive and supports pipeline integrity with a future recommendation on action limits.	
75	GO43	Alternative Caps for PE Service Tees (5.16.b)	164311228	Gas Operations	System Design & Materials		Materials and Equipment	2/15/2016	4/26/2023	$32,115	$112,400	$0	$32,115		Completed	$0	SCG $32,115.00 | OTD Members $80,285.00	Reliability, Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to develop an alternative cap design for polyethylene (PE) tapping tees. The alternate cap design enables the PE cap to be fused onto the tapping tee tower rather than having a cap that threads onto the tapping tee tower. A threaded cap has more potential for leakage due to inadequate O-ring seal engagement. A fused cap decreases the risk of leakage. Developing a fusion cap and tapping tee assembly has limitations, and the fitting developer requires alignment tools for performing socket fusion on the tee tower. Due to the cost of alignment tools needed for the operation, and the limitations in the original design, the project team developed a new design. Samples of the re-designed alternative caps are being manufactured and will be sent to sponsors for evaluation in 2023. SoCalGas can use this research as a reference to improve the integrity of PE piping systems and minimize operation and maintenance costs to repair leaks caused by threaded cap design.	
76	~~19~~GO44	ARPA-E REPAIR Program (TTSP)	20201028143729	Gas Operations	System Design & Materials		Materials and Equipment	10/1/2020	~~10/1/2023~~ 9/30/2024	$10,000	$325,654,637	$2,630	$7,370	$1,440	Active	$0	SCG $10,000.00 | DOE $32,554,637	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mulitple - Program supports various projects.	• Mulitple - Program supports various projects.	Old cast iron, wrought iron, and bare steel natural gas distribution pipes make up 3% of utility pipes in use, but account for a disproportionate number of gas leaks and pipe failures compared to newer steel pipe. The ARPA-E REPAIR program seeks to reduce natural gas leaks from these pipes by developing a suite of technologies to enable the automated construction of new pipe inside existing pipe. REPAIR will advance the state of gas distribution pipelines by incorporating smart functionality into structural coating materials and by developing new integrity/inspection tools. It will also create three-dimensional maps that integrate natural gas pipelines and adjacent underground infrastructure geospatial information with integrity, leak, and coating deposition data. SoCalGas involvement with the project is through the Testing and Technical Specification and Steering Panel Committee. In 2021, technical input was provided by operators. Draft test plans developed by the Testing and Analysis Team were sent out for comment in preparation for external loading, pressure and pressure testing on cast iron and bare steel pipe. .	
77	GO45	Corrosion Control Knowledge and Technology Integration for Safer California Natural Gas Pipeline System (GFO-21-506, Group 1)	20221121161346	Gas Operations	System Design & Materials		System Design	10/20/2022	12/31/2025	$5,000	$1,205,000	$100	$4,900	$100	Active	$0	SCG $5,000.00 | CEC $1,000,000.00 | Others $200,000.00	Reliability and Safety	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish Results; Technology & Knowledge Transfer/Training	The project objective is to develop an integrative approach for corrosion control of natural gas pipelines based on mitigation, monitoring, inspection, evaluation, and prediction. The research will address integration barriers with instrumentation, software, and training related to natural gas system integrity management, pertaining to microbially and soil property-influenced corrosion. The goal is to formulate a performance-based, cost-effective risk assessment and management approach and test the methodology in collaboration with pipeline operators in California. The project deliverables include: 1) evaluate corrosion detection technologies and improve existing and emerging pipeline inspection technologies; 2) integrate several corrosion risk models; and 3) develop a toolkit that could improve the accuracy, validity, and accessibility of data collection. The project plan is to develop training to increase data collection efficiency and accuracy and to validate the effectiveness of the Corrosion Risk Management toolkit with pipeline operators. SoCalGas believes that continued corrosion research is a necessary step in a good corrosion management process, and this project has the potential to benefit both California ratepayers and stakeholders by validating an advanced corrosion assessment methodology. SoCalGas will utilize the results of this research to evaluate and possibly augment its existing corrosion assessment processes.	
78	GO46	Crack Management Analysis Tool	20190904144711	Gas Operations	System Design & Materials		Risk Design and Modeling	12/29/2023	12/30/2024	$29,700	$152,000	$0	$29,700		Active	$0	SCG $29,700 | Others $152,000	Reliability, Safety, Improved Affordability	Late Stage (TRL 7-9)	Commercialization; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to support the development of an advanced web-based platform to help operators with post-processing in-line inspections (ILI) and non-destructive evaluation data for crack management. Utilities sometimes are limited to traditional Excel spread sheets to perform crack analysis or depend on third-party vendors to post-process sensitive information. This research will fill in the technology gap to help operators input large data sets and perform advanced analysis to help mitigate crack features on steel assets. The web-based platform will include crack evaluation, cycle counting analysis, refinement and evaluation of hard –to-spot crack features, probabilistic evaluation tools, flaw types (e.g., mechanical damage, corrosion), and multi-flaw remaining strength calculations. Project kickoff is scheduled for early 2024. Project deliverables include a web-based application, quarterly crack management workshops, and knowledge transfer. Results obtained from ILI inspections with crack detection tools will be deployed and evaluated using this web-based application. As SoCalGas increases its inspections of pipe segments using crack detection tools, the results of the research could optimize the effectiveness of inspection results and allow better understanding and assessment of pipe segments susceptible to cracking.	
79	GO47	Deliver Comprehensive Metal-Loss Assessment Criterion (EC-2-10)	20190907203828	Gas Operations	System Design & Materials		Pipeline Design	4/1/2019	4/30/2024	$133,902	$1,587,263	$133,902	$0		Active	$0	SCG $133,902.00 | PRCI Members $1,453,361.00	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Modification to Regulatory, Policy & Standards; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop Level 1 and Level 2 metal-loss assessment criterion that are easy to use and covers all pipe grades and construction eras. The metal-loss assessment criterion will indicate the risk of leak and rupture, reduce inspection data scatter, and eliminate maintenance that does not affect risk reduction. The project integrates and builds on work completed in prior research, which developed a criterion for metal-loss assessment demonstrated in an independent evaluation to significantly reduce data spread and address bias in contrast to the American Society of Mechanical Engineers (ASME) B31G and Modified B31G. These assessments will have less scatter and conservatism than ASME B31G, Modified B31G, and other assessment models without compromising pipeline operational safety. The project has four phases. Phase I was completed by developing a burst pressure predictive model for isolated metal loss that captures the effects of length, depth, width, planar shape, and longitudinal profile with the results provided in an interim report. Phases II and III are ongoing and are developing criteria to quantify interaction and coalescence for adjacent metal loss features, with the criteria to be evaluated relative to existing full-scale burst test data. In 2022, the project team continued finite element analysis of adjacent and nested metal loss features and started developing interaction and stacking rules for multiple metal loss features. The outcome of this effort will provide SoCalGas with a comprehensive and representative assessment of failure pressure in areas of corrosion damage.	
80	~~20~~GO48	Design and Placement of Compact Service Regulators - PHMSA Cofunding (5.22.j)	20211129162053	Gas Operations	System Design & Materials		Materials and Equipment	11/19/2021	5/31/202~~3~~5	~~5733~~ $54,848	~~489629~~ 645629	$54,848,000	$0		Active	$0	SCG $5,733 | OTD Members $590771~~105,904~~ | PHMSA $383,725	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	• Modification to Regulatory; Policy & Standards • Share/Publish Results	This project will review existing practices and perform comparative service regulator testing that will result in recommendations and guidance to the natural gas industry on "vent-limiting" service regulators. It will also provide additional options to natural gas utilities for the safe, outdoor installation of regulators and meter sets. This project will determine if "vent-limiting" service regulators offer more options for outdoor installation by having a smaller footprint and, thus, reduced clearance distances in comparison to traditional IRV service regulators. The project team will determine safe distance allowances through testing the quantity of gas vented during various regulator operating flow conditions and failure modes, including diaphragm ruptures. Many gas utilities have set a minimum distance to a source of ignition for both indoor and outdoor meters and regulators based on the National Fuel Gas Code's requirement. Field crews must satisfy these clearance distance requirements when installing meter set assemblies, including the regulator, on the outside of a building. These clearance distances, however, were created with standard internal relief valve regulators in mind. New "vent limiting" service regulators, typically with "slam shut" features, are now available from a few manufacturers and are being used in a limited fashion by some natural gas utilities. This project, which is co-funded by the Pipeline and Hazardous Materials Safety Administration, kicked off in November 2021. In 2022, the project team will develop the test plan; establish a Technical Advisory Committee of industry subject matter experts; identify national and international service regulators with "venting limiting" capabilities; and determine service regulators to be included in the test plan. .	
81	GO49	Digital MTR and Steel Pipe Traceability Pilot Project JIP (8.23.g)	20221121214815	Gas Operations	System Design & Materials		Tracking and Traceability of Materials	11/10/2022	11/29/2024	$30,000	$290,000	$30,000	$0		Active	$0	SCG $30,000.00 | OTD Members $150,000.00 | JIP Members $140,000.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to conduct a pilot project with manufacturers and operators to test the process of delivering, receiving, and retrieving digital Material Test Report (MTR) data. Most steel asset manufacturers apply a barcode that contains a serial number or another identification number. Some barcodes have asset attributes such as heat number, manufacturer, grade, diameter, and wall thickness. Each manufacturer defines the content and format of these barcodes, making them non-standardized. This lack of standardization makes it difficult for operators to use the data contained in the barcode consistently. The project goal is to start the process of achieving industry adoption of recently published American Petroleum Institute Recommended Practice 5MT - Pipeline Inspection Documents for Material Traceability and Electronic Test Reports (API 5MT) for digital MTRs and Global Standards 1 (GS1) for traceability barcodes for steel pipes. The project kicked off in Q4 2022. The project team will work on developing a GS1 standard, a barcode printing kit for manufacturers and coating mills, and a digital portal to link MTR from the barcode to the portal. If the pilot project is successful, the team will propose the next steps to continue the process of achieving industry adoption. With a digitized MTR process for collecting material data and properties, SoCalGas can improve efficiency and productivity during the MTR review in the quality assurance/quality control process.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
82	GO50	Distribution System Analysis	2023090822742	Gas Operations	System Design & Materials		Pipeline Design	12/1/2023	5/31/2026	$750,000	$750,000	$0	$750,000		Active	$0	SCG $750,000.00	Operational Efficiency, Improved Affordability, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results	This project's objective is to support future risk and threat analysis under different operating conditions by establishing families of pipes and components with specific characteristics that have similar risk profiles . The project will conduct a Critical Threat Review using a Phenomena Identification and Ranking Table (PIRT). This project will also develop an advanced probability-of-failure model by analyzing various parameters. Some of these parameters include material type, manufacturing process, prior pipeline inspection, operating histories, lab testing results, and existing probability-of-failure framework. By comparing the probability-of-failure of various pipelines, this project will help SoCalGas determine where replacements may be needed to accommodate future operations.	
83	GO51	Effect of Hydrogen Blended Natural Gas On Performance of Gas Meters and Diaphragm Type Service Regulators – Phase 1 (5.21.t)	202106230756	Gas Operations	System Design & Materials		Materials and Equipment	8/1/2021	7/31/2024	$50,757	$550,000	$50,757	$0		Active	$0	SCG $50,757.00 | OTD Members $499,243.00	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Field Demonstration/Validation Testing; Share/Publish Results	The objective of this project is to study the effect of hydrogen-natural gas (H2-NG) blends, with up to 20% hydrogen by volume, on the durability, safety, and performance of existing gas meters and diaphragm-type service regulators commonly used for residential service. Tests include durability, accuracy, leakage rates, and oxidation induction time. The results of the research project are anticipated to aid in understanding: 1) material compatibility impacts on gas meters and regulators in H2-NG blend service; 2) impacts of H2-NG blend H2 concentration on meter accuracy; and 3) feasible H2-NG blend limits for gas meters and service regulators. In 2022, the team finalized the bill of materials for three potential testing rig options. Sponsors chose to have two rigs set up, each with nine regulators and nine meters. The team received most of the meters required for this project, while nine regulators are still needed. The project team initiated the purchasing and subcontracting activities, delivery of parts for the testing rig setup, and construction of the testing rigs through the subcontractor. Project delays were due to project rescoping and supply chain issues on parts delivery. The next step is for GTI Energy to initiate purchase orders. The construction of the rigs is expected to begin in the first quarter of 2023, and completion is expected in the second quarter. The primary project deliverable will be a final report. SoCalGas could use the results from this research to contribute to creating a statewide hydrogen injection standard.	Hydrogen-Blending Project This project will be removed from the project portfolio per Resolution or final results and ratepayer benefits will be included in the 2024 Annual Report if approved in the Tier 2 Advice Letter.
84	GO52	Effect of Upstream Piping on Ultrasonic Meter Bias (MEAS-6-5C)	2018112612	Gas Operations	System Design & Materials		Equipment Design	11/1/2018	8/27/2023	$4,971	$236,000	$4,971	$0		Completed	$0	SCG $4,971.00 | PRCI Members $231,029.00	Reliability and Safety	Late Stage (TRL 7-9)	Technology & Knowledge Transfer/Training	The objectives of this project are to 1) assess the effect of end treatments on the velocity profile and the resulting ultrasonic meter (USM) performance, 2) develop an optimized end treatment design, and 3) evaluate the performance of a clamp-on USM in experimental testing. This project aligns with the Pipeline Research Council International (PRCI) goal to increase measurement accuracy. End treatments can cause distortions in the flow to USMs that can result in a reduction of flow meter performance and an increase in lost and unaccounted for (LAUF) gas. Currently, there are no public data for guidance or comparison of end-treatment designs. The primary benefits of this successful project are improved measurement uncertainty of USMs and reduced LAUF gas volumes from optimized end-treatment designs. The project team created computational fluid dynamics (CFD) models of six end treatments. The project team identified four end treatments for optimization and testing in 2020. Project sponsors voted to add two end treatments in optimization and testing and the collection of clamp-on USM data in the test plan in 2021. The project team started and completed experimental testing in 2022. The project team published a final report on the PRCI website for members. They will also give a webinar as the project's final presentation in early 2023. SoCalGas requested the performance testing of the new clamp-on USM model be added to the project scope to save the cost and time of conducting its evaluation. This approach allows for approved use at SoCalGas utility and customer sites.	
85	~~21~~GO53	Efficacy of Offline and Online Methodologies to Measure Siloxanes in RNG (MEAS-15-04)	20210622155310	Gas Operations	System Design & Materials		Gas Composition And Quality	8/31/2021	~~3/31/2023~~ 12/31/2024	$14,603	$118,000	$14,603	$0		Active	$0	SCG $14,603 | PRCI Members $103,397	Reliability and Safety	Late Stage (TRL 7-9)	• Modification to Regulatory; Policy & Standards • Share/Publish Results	The objective of this project is to determine the precision, accuracy, and sensitivity of the GC-IMS (Ion Mobility Spectroscopy) through the analysis of data from a second field test in partnership with OTD. GTI previously completed laboratory and field testing at a landfill site of the GC-IMS. The project team will further test an online GC-IMS siloxane sensor at a site differing in digester feedstock (such as WWTP) and geographic location from the initial tests to provide a more robust dataset. Following ASTM D8230 Standard Method for the Offline Analysis of Siloxanes in Biogas, periodic grab samples will be taken during the testing period and analyzed at laboratories. to compare the online data to offline analytical techniques. Additional renewable natural gas (RNG) pipeline specifications similar to ones in California are expected to be established. Producers, regulators, and utilities would benefit from validated and standardized measurement methodologies which meet these new, lower specifications. The ability to develop a low cost, low maintenance online analyzer capable of meeting the sensitivity and precision needs of the industry will allow suppliers to ensure near same-time compliance to regulations compared to offline analysis. .	
86	~~22~~GO54	Field Test NeverWet & Other Nano-Tech Coatings to Reduce Aboveground Corrosion (5.17.p)	2017102393	Gas Operations	System Design & Materials		Materials and Equipment	9/6/2017	~~3/31/2023~~ 6/30/2023	~~1347~~ 2775	$217,187,000	$2,775	~~$1,347~~ $0		Completed	$0	SCG $2,775~~1,347~~ | OTD Members $214,225~~185,653~~	Reliability and Safety	Mid Stage (TRL 4-6)	• Deployment of Results	This project investigates unique and promising coatings for challenging aboveground utility corrosion prevention applications. Corrosion is an ongoing threat to the integrity of metallic utility assets. For aboveground assets, one cannot rely on cathodic protection to back up coating protection. Therefore, specifying and applying the most appropriate and best-performing coating system is even more important. The unique and promising coatings that are available in the market have the potential to substantially reduce wet and dry aboveground corrosion in a wide variety of applications. Unfortunately, the NeverWet technology was discontinued, so it could not be included in the field trials. Field testing continues with three coatings being applied per the field test protocol. The project is in the planned "field exposure" phase, with the coatings logging time at their respective application sites. The plan was for the field test to include four seasons of exposure and then to assess performance. Due to COVID-19 restrictions, the field trial was extended. The extra time of exposure will benefit the meaningfulness of the assessments. To date, the applied systems continue to age in the field. .	
87	~~23~~GO55	Gas Machinery Research Council (GMRC)	20200102175422	Gas Operations	System Design & Materials		System Design	1/1/2019	12/31/202~~3~~4	$20,160	$1,464,000	$20,160	$0 ~~$3,840~~	$3,840	Active	$0	SCG $20,160 | GMRC Members $1,443,840	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mulitple - Program supports various projects.	• Mulitple - Program supports various projects.	With more than 70 member organizations, Gas Machinery Research Council (GMRC) is a community of natural gas companies dedicated to investigating technical issues within the rapidly evolving gas machinery industry and uncovering innovative solutions that improve the reliability, efficiency, and cost-effectiveness of mechanical and fluid systems. GMRC provides members and industry an opportunity to exchange information and ideas and participate in applied research and technology programs. GMRC accepts proposals relevant to current issues facing the gas machinery industry and seeking to improve the quality and efficiency of pipeline facilities and gas compressor stations. In 2021, GMRC active projects included: Dry Gas Seal Reliability (Phase 4), Virtual Orifice Performance Evaluation, Improvements in Elemental Sulfur Test Methods for Natural Gas, Hydrogen Blending Impacts on Compressor Stations (in partnership with Pipeline Research Council International), Hydrogen Impacts on O-Rings, and Improvements to National Institute of Standards and Technology (NIST) - Reference Fluid Thermodynamic and Transport Properties Database (RefProp) and Water-Hydrocarbon Vapor Liquid Equilibrium (VLE) Prediction (Phase 2). Three projects were completed in 2021 and results shared with members. .	
88	GO56	Gas Turbine Component Research Roadmap (CPS-5-12)	20230110232327	Gas Operations	System Design & Materials		Materials and Equipment	12/14/2022	3/31/2024	$16,912	$89,040	$8,872	$0	$5,482	Active	$0	SCG $16,912 | PRCI Members $72,128	Reliability, Safety, and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The projective objective is to develop a roadmap to guide future PRCI research in centrifugal components for gas turbine-driven centrifugal compressors. The last roadmap was created in 2016. That research map does not reflect the current state of technology. The team will perform a literature review under this new road map and survey the current state of gas turbine-driven centrifugal compressors. They will also identify gaps that will improve gas turbine-driven compressors' safety, reliability, and performance. Once the team develops the road map, they will use it to identify and prioritize research to benefit gas utilities and the ratepayers.	
89	GO57	Guidelines for Selecting Trenchless Installation Methods (CNST-1-4)	20230418213653	Gas Operations	System Design & Materials		Construction Design	12/1/2023	4/17/2024	$9,440	$118,000	$0	$9,440		Active	$0	SCG $9,440 | PRCI Members $108,560	Reliability and Safety	Late Stage (TRL 7-9)	Further Technology Development/Prototype; Deployment of Results; Technology & Knowledge Transfer/Training	This project's objectives are to develop a guideline outlining the currently available trenchless construction methods for pipeline installation, identifying their pros and cons, and to identify potential gaps or limitations that may lead to future trenchless technology innovation. Trenchless construction methods are used to install a pipeline around obstacles such as waterways, highways, and railroads, or to reduce potential environmental or community impacts. These methods may represent the most feasible and cost-effective option available. The project team intends to develop a guideline for the current state-of-theart trenchless construction methods based on selection criteria that include geographical formations, pipeline specifications, elevations, and depths. The guideline will include detailed information on the benefits, limits, and risks associated with each trenchless method to help determine which trenchless method may be more appropriate to utilize. SoCalGas will use the guideline for selecting, verifying, and utilizing the most appropriate and cost-effective trenchless construction methods for installing new pipelines or replacingexisting ones based on design and site conditions. This guidance should result in a safe and reliable pipeline installation, thereby minimizing environmental and community impacts that could cause disruptions in services or add additional costs to ratepayers.	
90	GO58	Hot Tap Branch Connections, JIP	20191210173947	Gas Operations	System Design & Materials		System Design	12/16/2019	9/20/2023	$30,000	$1,050,000	$30,000	$0		Completed	$0	SCG $30,000.00 | JIP Members $1,020,000.00	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Modifications to Regulatory, Policy & Standards, Share/Publish Results; Technology & Knowledge Transfer/Training	Hot tap branch connections have long been an important aspect of pipeline and piping system operations. This joint industry project (JIP) aims to develop industry best practices for welding stub-on branch connections onto live gas mains (i.e., hot taps) and to provide a guideline that enables the least-complicated procedure to be selected for a given application. Developing and using industry best practices for specifying and installing hot tap branch connections will reduce costs and increase safety and reliability. Previously, the team completed a report on in-service failures and guidance on fitting types and weld spacing. In 2022, the team completed the final version of the PRCI Pipeline Repair Manual. Additionally, revisions were made to the 22nd edition of API 1104, which is a global standard that supports industry-wide requirements for gas and arc welding used in the construction and in-service repair of pipes to improve pipeline safety, structural integrity, and efficiency by providing detailed welding procedures for qualified professional welders, inspectors, and engineers. The project team continues to work on qualifying procedures using a mechanized system for in-service welding, which can make longitudinal seam welds and circumferential fillet welds. The results of this JIP may aid SoCalGas in identifying instances where in-service welding may be acceptable or prohibited. It could also allow it to realize significant economic and environmental benefits.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
91	~~24~~GO59	HyBlend Collaborative Research Partnership (5.21.k)	2021062301611	Gas Operations	System Design & Materials		System Design	9/1/2021	~~7/31/2023~~ 9/28/2024	$50,000	$15,050,000	$50,000	$0		Active	$0	SCG $50,000 | OTD Members: $4,100,000 | DOE: $10,900,000	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mulitple - Program supports various projects.	• Mulitple - Program supports various projects.	Begun in August 2021, the HyBlend Project is a joint effort of national labs, natural gas operators, and research consortia to evaluate technical and economic considerations associated with transporting hydrogen blends and other low-carbon fuels using existing gas infrastructure. The project team is addressing many topics related to hydrogen blending, including hydrogen compatibility with metals and polymers, life cycle analysis, techno-economic analysis, and building equipment. Five national labs will lead the research. Sandia National Laboratory will lead development of general pipeline integrity guidance for operating natural gas transmission and distribution systems with hydrogen blends by assessing the role of these blends in the degradation of metal pipelines. Pacific Northwest National Laboratory will lead the assessment of hydrogen blends on the degradation of polymer pipelines and material lifespan. Argonne National Laboratory will lead the life cycle analysis of technology pathways for hydrogen blends. The National Renewable Energy Laboratory will lead the quantification of costs and opportunities for hydrogen production and blending within the natural gas system. Oak Ridge National Laboratory will lead the evaluation of residential, commercial, and industrial end uses with hydrogen blends, assessing safety, emissions, reliability, and energy efficiency. In 2021, the team began establishing test conditions and materials and working on a literature review of global research and experience in operating natural gas pipeline systems with hydrogen blends. The team will publish a compilation of reports and white papers at project completion. SoCalGas will use these results to support the development of a hydrogen blending standard and to guide future research. .	Hydrogen-Blending Project This project will be removed from the project portfolio per Resolution or final results and ratepayer benefits will be included in the 2024 Annual Report if approved in the Tier 2 Advice Letter.
92	GO60	Hydrogen Blending Impact on Aldyl-A and HDPE Pipes (5.21.j)	2021070217132	Gas Operations	System Design & Materials		Materials and Equipment	4/8/2021	3/31/2024	$493,503	$952,403	$493,503	$0		Active	$0	SCG $493,03.00 | OTD Members $458,900.00	Reliability and Safety	Late Stage (TRL 7-9)	New Research Project to Advance TRL; Field Demonstration/Validation Testing	This project will develop a lifetime-prediction and associated risk model for Aldyl-A and vintage High-Density Polyethylene (HDPE) pipes pressurized with a blend of natural gas and hydrogen. SoCalGas is interested in understanding how the interaction between hydrogen and chemical additives in the resin could lead to chemical degradation and lower resistance to slow crack growth. It is also of interest to understand the physical interaction of hydrogen and materials at the crack tip of micro-fractures leading to accelerated crack growth. It is crucial to understand the impact of hydrogen blends on the existing PE infrastructure to maintain the integrity and safety of gas distribution pipelines. Risk impact due to hydrogen blending must be quantified so operating procedures and associated budgets can be adjusted accordingly. Long-term strength tests, tensile tests, and several material tests will be performed to observe the material's behavior in the hydrogen/natural gas blend and to develop the lifetime prediction and risk models. Aldyl-A and HDPE Pipe samples have been collected, and the Oxidation Induction Time, Cross-Polarized Light Microscopy, and Tensile tests have been completed. The construction and shakedown of the testing apparatus for the Long-Term Hydrostatic Strength tests took some time due to resource issues, which delayed the tests. Testing of Aldyl-A samples has been completed. HDPE testing is planned for the beginning of 2023.	Hydrogen-Blending Project This project will be removed from the project portfolio per Resolution or final results and ratepayer benefits will be included in the 2024 Annual Report if approved in the Tier 2 Advice Letter.
93	GO61	Hydrogen Embrittlement and Crack Growth (Phase 2)	20200720173851	Gas Operations	System Design & Materials		Gas Composition And Quality	12/15/2020	5/31/2023	$285,466	$285,466	$285,466	$0		Completed	$0	SCG $285,466.00 | None $0.00	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results	The project objective is to characterize the Fatigue Crack Growth Rate (FCGR) behavior of different steel pipe grades in a range of hydrogen-natural gas blends. The team will determine the FCGR for base metals, longitudinal seam welds, and girth welds at both the weld center line and Heat-Affected Zone (HAZ). Each phase or subphase will test one pipe grade: Phase 1a (X70), Phase 1b (X52 and X65), and Phase 2 (vintage X42 and X52). In 2021, the project team completed Phase 1a. The results showed that the FCGR accelerated for the various microstructures in the environments (i.e., hydrogen blends) caused by hydrogen embrittlement mechanisms. This finding expanded the project's scope to include testing for microstructural characterization since defects in microstructure strongly influence crack initiation processes. The team performed a complementary microscopy study for new API X65 steel samples. In 2022, the project team completed the testing for Phase 1b, the microscopy study, and Phase 2. The new X52 testing baseline results of the base metal showed similar trends as X70 and X65 pipes. The team delivered the final report for Phase 1B in December 2022, and they expect the final reports for the microscopy study and Phase 2 in January 2023. SoCalGas will use this knowledge to understand the effects of hydrogen embrittlement on steel pipes and to direct additional research.	Hydrogen-Blending Project The project was completed prior to Resolution.
94	GO62	Identification and Development of an Analyzer for Siloxane Measurement (M2018-010) Ph II	20200630211156	Gas Operations	System Design & Materials		Gas Composition And Quality	1/31/2021	1/31/2023	$28,940	$256,203	$28,940	$0		Completed	$0	SCG $28,940.00 | NYSEARCH Members $227,263.00	Reliability and Safety	Mid Stage (TRL 4-6)	Further Technology Development/Prototype; Technology & Knowledge Transfer/Training;	The overall goal of this project was to find a robust measurement method that could detect Siloxanes in renewable natural gas (RNG). Siloxanes are man-made organic compounds that contain silicon, oxygen, and methyl groups. Silicon compounds are commonly found in personal hygiene, health care, and industrial products leading to the formation of siloxane in biomethane produced from the anaerobic digestion of waste from landfills and wastewater treatment plants. Combustion of renewable natural gas (RNG) containing siloxanes produces a silica deposit on downstream surfaces that can impact the safety and reliability of appliances and the efficiency of industrial equipment. The Phase II objective was to identify a suitable portable technology that can measure low levels of siloxane concentrations (~0.1 mg Si/m3) and to test the instrument in a wide range of applications. Previously, in phase I of this project, the team evaluated analyzers in the laboratory and the field to provide the technology options for Phase II. During phase II, the team gathered data and information on the presence of siloxanes in RNG that can be used to develop a standard on acceptable siloxane levels. The team chose five analyzers, and testing was conducted for accuracy and reproducibility using the new American Society for Testing and Materials standard. An interim report of the results will help funders determine the analyzer(s) to be evaluated in the next step during field testing.	
95	~~25~~GO63	Impact of Blended H2 on Threaded Connections (M2021-007)	20210810214230	Gas Operations	System Design & Materials		System Design	8/9/2021	3/31/2023	$19,011	$213,092	$19,011	$0		Completed	$0	SCG $19,011 | NYSEARCH Members $194,081	Reliability, Safety, and Environmental: Reduced GHG Emissions	Early Stage (TRL1-3)	• New Research Project to Advance TRL Level • Modification to Regulatory; Policy & Standards • Share/Publish Results	The objective of this project is to determine if hydrogen blends in natural gas cause any change in 1) the presence or absence of leaks and 2) the leak flow rate for threaded connections. This project consists of four tasks involving threaded connections that conform to National Pipe Thread (NPT) standards. In Task 1, the team is developing test protocols and determining the test sample size. Tasks 2 and 3 includes tests to determine the change in a leak or leak flow rate with a 20% hydrogen blend. In Task 4, the project team will determine the impact of various pipe dope and sealants and if hydrogen blends influence this variable. The team will also perform tests on non-NPT threaded connections. The project kicked off in October 2021 establishing procedures for creating threaded connection leaks and methods to measure leak flow rates with hydrogen blends. SoCalGas will use this data to support the determination of a hydrogen blend limit for natural gas distribution systems that will contribute to a statewide hydrogen injection standard. .	Hydrogen-Blending Project The project was completed prior to Resolution.
96	~~26~~GO64	Impact of Hydrogen/Natural Gas Blends on LDC Infrastructure Integrity (M2020-002 PhII)	2020052652138	Gas Operations	System Design & Materials		Gas Composition And Quality	4/22/2021	6/30/2023	$31,910	$425,024	$31,910	$0		Completed	$0	SCG $31,910 | NYSEARCH Members $393,114	Reliability and Safety	Mid Stage (TRL 4-6)	• New Research Project to Advance TRL Level • Modification to Regulatory, Policy, Standards	The objective of this project is to determine if blending hydrogen into natural gas will change the physical properties of elastomers in a natural gas delivery system, the most common of which are styrene-butadiene rubber (SBR) and acrylonitrile butadiene rubber (NBR). Both are used as seals in compression applications and as gaskets for flanges in joining pipes and fittings. The lack of data on the effect of hydrogen concentrations in hydrogen/natural gas blends on elastomers in a natural gas infrastructure (e.g., piping, piping components, and appurtenances) may impact the safety and reliability of the gas delivery system. In Phase 1, the team performed exploratory tests using a limited set of test gas mixtures. Phase 2 will involve further tests on field-extracted and virgin materials using an expanded set of test gases. The team completed Phase 1 in April 2021 with a preliminary assessment of the impact of varying hydrogen concentrations in methane/hydrogen blends on the mechanical and physical properties of SBR and NBR elastomers in common use as coupling materials used to join metal pipes. Results from Phase 1 found that unrestrained SBR cubes exhibited a change during creep tests with a dimensional change and a reduction in elasticity. Phase 2 will leverage findings from Phase 1 and test new and vintage materials with a wide range of hydrogen blends (up to 20%), pressures, and temperatures. To date, the team has completed stress relaxation analysis for NBR and SBR materials at 5% hydrogen. The next step is to evaluate 20% hydrogen blends and constant load performance. This project will help SoCalGas determine if and how hydrogen blends will affect the physical properties of typical elastomers and the hydrogen blend level that the existing natural gas system can tolerate.	Hydrogen-Blending Project The project was completed prior to Resolution.
97	~~27~~GO65	Implementing API 5L RP 5MT, "Pipeline Inspection Documents for Material Traceability and Electronic Test Reports " (8.22.c)	20220114185642	Gas Operations	System Design & Materials		Materials and Equipment	3/1/2022	~~6/30/2023~~ 5/30/2024	$13,831	$255,000	~~8000~~ $13,831	~~5831~~ $0		Active	$0	SCG $13,831 | OTD Members $241,169	Reliability, Safety, Operational Efficiency, and Improved Affordability	Early Stage (TRL 1-3)	• Modification to Regulatory; Policy & Standards • Deployment of Results	American Petroleum Institute (API) Standard 5L is the standard for transmission pipes used in the natural gas and petroleum industries. This standard governs specifications for seamless and welded steel pipes of different grades. These specifications are validated with tests, and the results are published in a specification report for each type of steel and grade. Suppliers currently provide their reports in paper form. The goal of this project is to develop an electronic form of the report for manufacturers to use. The team will develop a digital template to make the report available to customers electronically. A common standard for electronic reports streamlines industry efforts. The project will also develop a method for verification that the report is from the manufacturer of the pipe. This will improve traceability by providing an electronic signature that ties the test report directly to the manufacturer. .	
98	GO66	Individual Packaging Requirement for all Bulk Packaged Plastic Fittings (5.24.g)	20240104172619	Gas Operations	System Design & Materials		Materials and Equipment - Pipes & Fittings	12/1/2023	6/1/2025	$83,083	$152,000	$0	$83,083		Active	$0	SCG $83,083 | OTD Members $68,917	Operational Efficiency, and Improved Affordability	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results	The objectives of this project are to develop the requirements for individual packaging of plastic fittings and incorporate the requirements in the applicable American Society of Testing and Materials (ASTM) standards. Joining polyethylene (PE) pipe is a fundamental activity performed by every gas utility across the country. Utilities are seeking to enhance the integrity of PE fusions. Although the failure rate for PE fusions is quite low, the consequences of these limited failures can be significant. Pipe and fitting contamination is one of the leading causes of joint integrity issues. Currently, there is no mandatory requirement or guidance for plastic fittings to be packaged individually when they are provided in "bulk" packaging. This can result in potential contamination or dislodged and/or missing components such as O-rings or fasteners. Requiring individual packaging of all products will improve overall system integrity by reducing the risk of fitting contamination and/or displaced fitting components. The team will work with the project sponsors to identify the ASTM standard(s) to update, create the appropriate packaging language to require individual component packaging when bulk packaging is used, and work to incorporate this new natural gas industry language into the appropriate ASTM standards. This project will improve the integrity of SoCalGas' plastic piping systems by minimizing or eliminating the risk of using potentially contaminated fittings during installations. It would also prevent or minimize the operations cost associated with repairing leaks due to contaminated joints.	
99	~~28~~GO67	Integrity Impact of HAZ Softening on Type-B Sleeves and Hot Tap on Modern Steel (SBD-1-6A)	2021101422849	Gas Operations	System Design & Materials		System Design	10/13/2021	10/13/2023	$13,587	$177,000	$13,587	$0		Completed	$0	SCG $13,587 | PRCI Members $163,413	Reliability and Safety	Early Stage (TRL 1-3)	• Field Demonstration/Validation Testing	Heat Affected Zone (HAZ) softening occurs in girth welds on pipelines. The HAZ area loses mechanical strength which creates a mismatch between mechanical properties of the pipe and the HAZ. Girth welds are not only used in pipeline construction but are also used in some pipeline repairs. Type-B sleeves are one such repair type. The sleeve is welded to the pipeline to repair leaks and damaged section of the pipeline. HAZ also occurs in another repair method -hot taps. This project investigates HAZ softening in Type-B sleeves and hot taps in pipeline repairs. Tests will be performed to test different welding and installation procedures to minimize the loss of mechanical strength in HAZ. A final report will be delivered with recommended welding and installation procedures for using Type-B sleeves and hot taps. This project will enhance pipeline integrity by minimizing pipeline failures. .	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
100	GO68	LUAF Study	2023082323286	Gas Operations	System Design & Materials	_	Materials and Equipment	12/1/2023	3/31/2024	$70,975	$70,975	$0	$70,975	_	Active	$0	SCG $70,975.00 | None $0.00	Reliability,Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	The objective of this project is to characterize and estimate the measurement- and theft-related variables for lost and unaccounted-for (LUAF) gas volumes on the SoCalGas delivery system. The original SoCalGas study on determining LUAF gas volumes was developed by the Gas Research Institute in the early 1990's (GRI report 93/0115). An update to the report looking specifically at the measurement factor was conducted in 2006 by SoCalGas . Since then, equipment and operating practices have changed greatly, especially with the introduction of new technology. Historically, measurement has accounted for the greatest percentage of SoCalGas LUAF. However, the contribution of natural gas theft to LUAF estimates has been difficult to define; it is known that new methods of theft have been identified in recent years. This project will perform a detailed analysis of 1) the metering technology and components within SoCalGas for 2018-2022, and 2) the main areas of annual variability, identifying the factors and variables that affect SoCalGas customer service and theft-related distribution LUAF. The project deliverables will include two final reports: measurement-related LUAF and theft-related LUAF. Each report will include recommendations for future consideration (if warranted). The knowledge gained from the results will be used to provide recommendations for ways to make SoCalGas systems more efficient. If the results precisely identify the current contribution of the measurement and theft components of LUAF and identify the ways to reduce measurement and theft LUAF in the future, then SoCalGas would implement the identified areas of improvement.	
101	~~30~~GO69	Managing Stress From Uneven Support & Settlement (CNST-2-2A)	2022042722280	Gas Operations	System Design & Materials	_	System Design	3/25/2022	3/25/2024	$15,234	$188,000	~~0~~ $15,234	~~15234~~ $0	_	Active	$0	SCG $15,234 | PRCI Members $172,766	Reliability and Safety	Mid Stage (TRL 4-6)	• Deployment of Results • Share/Publish Results	The objective of this project is to develop guidelines and procedures to manage strain and stress from uneven support and soil settlement in the design, construction, and maintenance of pipelines. High strain and stress could lead to fractures in pipelines causing failures and disruption to services for ratepayers. This project will investigate current practices of utilities to address external strain and stress. The project team plans to investigate excavation and backfill practices that cause high strain and stress by gathering utility data for analysis. The team also plans to delve deeper into the subject by covering terrain conditions that may contribute to higher strain and stress. Model simulations will be used to simulate and quantify the strain and stress to develop best practices to minimize strain and stress on pipelines. In addition to delivering the guideline and procedure for best practices, the project team will hold a workshop to train utilities on how to implement the best practices to minimize strain and stress on pipelines. The outcome of this project will lead to better integrity management of gas pipelines to prevent failures from uneven support and settlement of pipelines, making the pipeline system safer and more resilient. SoCalGas supported this project in anticipation that the guidelines and procedures for best practices could improve design, construction, and maintenance to minimize strain and stress on its pipelines. .	
102	GO70	MAOP and Materials Verification - Phase I (4.17.d)	2017092812	Gas Operations	System Design & Materials	_	Tracking and Traceability of Materials	9/8/2017	2/28/2023	$11,364	$116,000	$11,364	$0	_	Completed	$0	SCG $4,364.00 | OTD Members $91,636.00	Reliability and Safety	Mid Stage (TRL 4-6)	Technology & Knowledge Transfer/Training	The project objective is to provide software tools to assist operators in complying with the maximum allowable operating pressure (MAOP) and materials verification requirements in the proposed rule on the Integrity Verification Process (IVP). The proposed guideline allows using Engineering Critical Assessments (ECA) instead of a hydrotest, derating, or pipe replacement. The pending rule also allows pipe surface-based non-destructive measurements instead of cutouts and reduces the number of destructive tests. The team has developed a set of models using the ASME B31G-modified (wall loss defects) and the Maxey-Folias Leak-Rupture Boundary model and shared them with the Specified Maximum Yield Stress Boundary Project. The design work continues with the development of modules for the ECA tools. The project team has also identified a new compiler/computer language to replace Fortran/Ruby language-based tools and improve computer performance for new and existing models. The project team has made significant progress in importing the ten-million-point dataset and using it in model calculations with resulting output in spreadsheet format. The team plans to continue the development of additional modules for the ECA tools. Project deliverables will include the developed modules along with a final report. SoCalGas could use this tool to comply with the proposed IVP Rule.	
103	GO71	Microstructural Characterization of Pipe Steels Exposed to Hydrogen Blends	202105287156	Gas Operations	System Design & Materials	_	Gas Composition And Quality	5/1/2021	5/31/2023	$78,500	$78,500	$78,500	$0	_	Completed	$0	SCG $78,500.00 | None $0.00	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results	The project objective is to characterize the Fatigue Crack Growth Rate (FCGR) behavior of different steel pipe grades in a range of hydrogen-natural gas blends. The team will determine the FCGR for base metals, longitudinal seam welds, and girth welds at both the weld center line and Heat-Affected Zone (HAZ). Each phase or subphase will test one pipe grade: Phase 1a (X70), Phase 1b (X52 and X65), and Phase 2 (vintage X42 and X52). In 2021, the project team completed Phase 1a. The results showed that the FCGR accelerated for the various microstructures in the environments (i.e., hydrogen blends) caused by hydrogen embrittlement mechanisms. This finding expanded the project's scope to include testing for microstructural characterization since defects in microstructure strongly influence crack initiation processes. The team performed a complementary microscopy study for new API X65 steel samples. In 2022, the project team completed the testing for Phase 1b, the microscopy study, and Phase 2. The new X52 testing baseline results of the base metal showed similar trends as X70 and X65 pipes. The team delivered the final report for Phase 1B in December 2022, and they expect the final reports for the microscopy study and Phase 2 in January 2023. SoCalGas will use this knowledge to understand the effects of hydrogen embrittlement on steel pipes and to direct additional research.	Hydrogen-Blending Project The project was completed prior to Resolution.
104	GO72	Multi-Compound Green Corrosion Inhibitor for Gas Pipeline	20240110234318	Gas Operations	System Design & Materials	_	Corrosion System Design	12/1/2023	9/29/2026	$4,000	$1,004,000	$0	$4,000	_	Active	$0	SCG $4000 | PHMSA $1,000,000	Reliability, Safety, Operational Efficiency	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this Pipeline and Hazardous Material Safety Administration co-funded project is to develop a novel "green" corrosion inhibitor, optimize its implementation in gas pipeline environments, and evaluate the inhibitor's effectiveness and compatibility through laboratory testing and nondestructive evaluation measurements. Compared to traditional chemical inhibitors, green corrosion inhibitors may offer great potential to mitigate internal corrosion, while being environmentally friendly. This project will evaluate and test multi-compound green inhibitors derived from renewable feedstocks for performance. The project team will simulate the implementation to recommend best practices for different pipe geometries, inhibitor properties, and operational factors. Validation testing will include inhibitor coating thickness, gas properties, and pipeline properties. In 2023, the project team worked on the design and synthesis of green inhibitors and explored potential candidates for green corrosion inhibitors suitable for gas pipeline protection. The next step is to develop the test protocols. SoCalGas anticipates using environmentally friendly alternatives to prevent corrosion in pipelines. The research could help identify features for Integrity Management, which will benefit ratepayers by improving operational efficiencyand safety, while reducing the environmental impact of using corrosion inhibitors to protect the pipelines.	
105	~~31~~GO73	On-Line Biomethane Gas Quality Monitoring Ph III (7.16.e.3)	2021062301148	Gas Operations	System Design & Materials	_	Gas Composition And Quality	8/1/2021	~~3/31/2023~~ 12/31/2024	$56,439	$267,000	$56,439	$0	_	Active	$0	SCG $56,439 | OTD Members $210,561	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	• Field Demonstration/Validation Testing • Share/Publish Results	In past phases of this project, validation testing on several on-line biomethane analyzers were performed to identify which would have the potential to detect unconventional trace constituents. Two analyzers were proposed for consideration for further development under Phase 3. The goal of Phase 3 is to perform product development on the selected analyzer and to test the modified analyzer to validate the monitoring of the unconventional trace contaminants. These trace constituents are sometimes found in biomethane if cleanup technologies fail. These unconventional trace constituents are not routinely monitored by on-line instruments but are critical to gas quality. Utilities need technologies to provide real-time gas quality data for these trace constituents. In this phase, the analyzer manufacturer will work to modify their system to incorporate changes identified in Phase II with the goal of commercializing the analyzer. The newly developed on-line analyzer will be tested with continuous gas streams compared to laboratory measurements following standard methods to evaluate precision, accuracy, and operational experience. The deliverable will be a market-ready analyzer, available for field tests, which can monitor the predominant species of ethylbenzene, toluene, siloxanes, organic arsenics, halogenated hydrocarbons, and n-nitroso-di-n-propylamine. Once available, this analyzer could be installed at locations where there is a potential for trace constituents above the limits. The project kick-off meeting was held in November 2021, and sponsors discussed which analyzer should be developed further after reviewing data on cost and maintainability. The next step is to finalize the analyzer selection. .	
106	~~32~~GO74	Optimize the Detection and Mitigation of Mechanical Damage (SRP-MD-01)	20210720171815	Gas Operations	System Design & Materials	_	Materials and Equipment	1/1/2021	12/31/202~~3~~4	~~7370~~ 75,000	$2,042,507	~~7370~~ 49,040	$25,960	_	Active	$0	SCG $75,000~~370~~ | PRCI Members $~~2,035,137~~1,967,507	Reliability and Safety	Mulitple - Program supports various projects.	• Mulitple - Program supports various projects.	Detecting and mitigating mechanical damage to pipeline infrastructure is a major concern to the natural gas industry. The Pipeline Research Council International established this Strategic Research Priority (SRP) to coordinate the efforts across all technical committees (Compressor Pump Station, Design Materials Construction, Surveillance Operations Monitoring, Measurement and Underground Storage). The SRP goal is to provide a roadmap of research projects to close the gaps on mechanical damage (MD) research and to produce a comprehensive set of guidelines and tools for managing the threat of MD. The SRP funded one project in 2021: Analysis of Pipeline Operator and Prior R&D Data (MD-2-5). An additional SRP project will be added in 2022: Improvements to Mechanical Damage Engineering Assessment Tool (MD-2-4). .	
107	~~33~~GO75	Pathway to Achieving Efficient and Effective Crack Management (SRP-CM-01)	2021072171434	Gas Operations	System Design & Materials	_	Materials and Equipment	1/1/2021	12/31/202~~3~~4	~~23819~~ 75,000	$5,193,400	~~23819~~ 73,095	$1,905	_	Active	$0	SCG $~~23,819~~75,000 | PRCI Members $5,~~169,581~~118,400	Reliability and Safety	Mulitple - Program supports various projects.	• Mulitple - Program supports various projects.	This research intends to advance critical areas associated with the execution of crack management programs that eliminate crack-related failures. The Pipeline Research Council International established this strategic research priority (SRP) to coordinate efforts across all the technical committees (Compressor Pump Station, Design Materials Construction, Surveillance Operations Monitoring, Measurement, and Underground Storage). The goal of the SRP is to provide a roadmap of research projects to further understand and efficiently and effectively manage cracks in pipelines. Research will focus on four core areas: susceptibility, inspection, management, and assessment and remediation. The SRP funded two projects in 2021: Understanding Why Cracks Fail (MAT-8-3), and Improvement of ILI Capabilities Joint Industry Project (PHASE II) (NDE-4-12). .	
108	GO76	Pipeline Integrity Tool Cloud Based Assessment Software Consortium Project (MAT-8A/JCAS-01)	20200116212934	Gas Operations	System Design & Materials	_	System Design	9/1/2019	12/31/2024	$67,645	$621,695	$67,645	$0	_	Active	$0	SCG $67,645.00 | PRCI Members $554,050.00	Reliability, Safety, and Improved Affordability	Late Stage (TRL 7-9)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing; Deployment of Results; Technology & Knowledge Transfer/Training;	The objectives of this joint industry project (JIP) are to develop an improved model for pipeline seam weld anomalies and to improve the existing Pipeline Research Council International (PRCI) MAT-8A fracture mechanics model and its input parameters. The final product will be a cloud-based software that uses probabilistic fracture mechanics (PFM) with the updated MAT-8 model. The new software enables operators to optimize resources by evaluating different mitigation scenarios. In 2022, the project team conducted training sessions for sponsors on fracture mechanics, probability concepts, and the cloud-based software. Evaluation of the methodology to analyze populations of non-detected defects against PRCI methodology is ongoing. At the conclusion of this project, a report and updated model in the form of cloud-based software will be delivered to the project participants. SoCalGas will use these results to make informed decisions when conducting Engineering Critical Analysis (ECA) for various applications such as general fitness for service, maximum allowable operating pressure reconfirmation, and In-Line Inspection (ILI) tool validation. The anticipated development of an analysis methodology for undetected populations of cracks in pipelines could assist SoCalGas in performing this type of analysis for ECA without ILI to support regulatory requirements because of the Gas Transmission Safety Rule.	
109	~~34~~GO77	Practical Girth Weld Evaluation Criteria Considering Weld Strength Mismatch and HAZ Softening (MATH-5-3D)	20211013141320	Gas Operations	System Design & Materials	_	System Design	10/5/2021	~~4/5/2023~~ 5/31/2024	$14,350	$212,400	$14,350	$0	_	Active	$0	SCG $14,350 | PRCI Members $198,050	Reliability and Safety	Mid Stage (TRL 4-6)	• Modification to Regulatory; Policy & Standards • Share/Publish Results	This project continues work from previous girth weld research projects for which new testing methods and welding guidance documents were developed (MATH-5-3B and MATH-5-3C.) This project uses these results to propose revisions to current welding standards - the American Petroleum Standard 1104 and Canadian Standard Association Z662- to address girth weld strength mismatch. These revisions will improve pipeline integrity, safety, and reliability of pipelines by updating the standards with new testing methods and new procedures for minimizing heat affected zone (HAZ) softening near girth welds to prevent strength mismatch. .	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
110	GO78	PRCI Emerging Fuels Institute	20210824201539	Gas Operations	System Design & Materials		Gas Composition And Quality	6/15/2021	12/31/2026	$750,000	$5,475,000	$750,000	$0	$250,000	Active	$0	SCG $675,000.00 | PRCI Members $4,800,000.00	Reliability, Safety, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Multiple - Program supports various projects.	Multiple - Program supports various projects.	Pipeline Research Council International (PRCI) established the Emerging Fuels Institute (EFI) in April 2021 to address the challenges of transitioning to clean fuels. The EFI will focus on infrastructure related to various emerging fuels, such as renewable natural gas (RNG), ammonia, and biofuels. The EFI focuses on the following areas: pipeline system integrity; steel and non-steel components; compressor stations, pressure control, and over-pressure safety devices; electrical classification and fire safety; and underground storage. In 2023, the EFI funded several new projects, which included: EFI Guidance Document (JEFI-00-02); Emerging Fuel Measurement (JEFI-02-03); B31.4, B31.8, B31.12, and Emerging Fuels Discussion (JEFI-04-10); the Department of Energy's SHASTA Program (JEFI-05-02); and Implement Fiber Optic Technology for Underground Gas Storage Well Monitoring, a Pipeline and Hazardous Materials Safety Administration project. Additionally, work continues on the following previously funded projects: RNG Trace Components Database (EFI-02-01); NewGasMet/PRCI Collaboration; and EFI Talking Points (EFI-00-01). Participation in the EFI enhances SoCalGas' knowledge and expands its knowledge library to assist in improving the safety of its pipeline network infrastructure.	
111	GO79	PRCI Guidance Document for the Twenty-Second Edition of API 1104 (API-1-2B)	20230911161744	Gas Operations	System Design & Materials		Equipment Design	12/1/2023	5/2/2024	$9,963	$241,900	$0	$9,963		Active	$0	SCG $9,963 | PRCI Members $231,937	Reliability, Safety, Improved Affordability	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results	The objective of this project is to update the Pipeline Research Council International guidance document for the Twenty-second Edition of American Petroleum Institute (API) Standard 1104 – Welding of Pipelines and Related Facilities (API 1104). The development of the updated guidance document will enable both users and regulators to better understand the intent regarding the interpretation and rationale behind the requirements. The use of this updated guidance document will increase the safety and reliability of newly constructed pipelines by helping avoid misinterpretation of requirements. It will also enable users to confidently tailor welding procedures to better fit the requirements of their specific needs within the bounds of API 1104. This may, in turn, reduce the cost of pipeline construction and maintenance activities. The milestone deliverables include: 1) outline of guidance to address industry needs, 2) outline of guidance required for the Twenty-second Edition, and 3) summarizing the changes between the Twenty-first and Twenty-second Editions of API 1104. In 2023, the project team developed an outline to address industry needs for the Twenty-second Edition and compiled a summary of the changes between the Twenty-first and Twenty-second. Anticipated ratepayer benefits include integrity, safety, reliability, and improving affordability through cost reductions. SoCalGas will deploy these results to update its existing welding procedures that reference API 1104.	
112	GO80	Product Standards for Plastic Tapping Tees (5.24.f)	20240104171815	Gas Operations	System Design & Materials		Materials and Equipment - Pipes & Fittings	12/1/2023	12/1/2025	$66,000	$220,000	$0	$66,000		Active	$0	SCG $66,000 | OTD Members $154,000	Operational Efficiency, and Improved Affordability	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Deployment of Results	The objective of this project is to develop a draft product standard document for tapping tees. The developed draft product standards can be used by operators for purchasing specifications and may be used to develop American Society of Testing and Materials (ASTM) standards. Currently there are no defined product standards that manufactured tapping tees must meet. There is a standard for the tees to ensure a certain level of joint integrity, but not for the plastic tee fitting itself. The materials used and the overall design and dimensions of these tapping tees can impact the performance of these fittings. History has shown that improper selection of materials or poor fitting designs can lead to premature failure of the fitting. Creating a product standard for conventional heat fusion tees will ensure that the tees uphold certain standards for fitting quality and performance. There are a lot of variables that need to be considered regarding how tapping tee fittings are designed, manufactured, and tested. The project aims to create a task team to develop specifications for tapping tees. The specifications will include overall design, dimensions, and geometrical considerations, and fitting component requirements. The project team will identify all the design criteria and determine what stresses the components are designed for, establish the types of failure for each component, and aim to design out the issue that could ultimately lead to failure. The project will develop a test protocol for each component and testing will be carried out per industry and consensus standards to determine if they meet a specific performance requirement. This project will help SoCalGas in review of their material specification requirements for tapping tees.	
113	GO81	Reserve Strain Capacity Determination	20221027175356	Gas Operations	System Design & Materials		Materials and Equipment	3/30/2022	10/30/2024	$2,500	$1,936,008	$600	$1,900	$100	Active	$0	SCG $2,500.00 | OTD Members $496,000.00 | PHMSA $1437,508.00	Reliability and Safety	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Modification to Regulatory Policy & Standards; Share/Publish Results; Technology & Knowledge Transfer/Training	This project aims to develop a model for measuring accumulated strain on existing pipelines. The team will accomplish this by developing and demonstrating a model network for predictive modeling with decision nodes to show a decision path's outcome (diagrams). The project will also employ the following: 1) scenario analysis for strain interventions, 2) satellite-based ground movement data, 3) causal models for pipeline modes of failures, and 4) metallurgical influences on pipeline properties, which are all required to develop a model to measure accumulated pipeline strains. Satellite data can be used to assess the strains on existing pipes. Metallurgical influences can help reveal the behavior of the steel pipeline and damage propagation in the steel under interacting threats. This Pipeline and Hazardous Materials Safety Administration (PHMSA) co-funded project will provide the necessary modeling and data analysis framework to correlate satellite-based ground movement data to strains on pipelines of interest. In 2022, the project team identified potential sites where satellite and standard data correlate with pipe movement and strain measurement. The development of causal models for multiple pipeline modes of failure and the identification of metallurgical influences on pipeline properties are ongoing. The initial modeling feedback gave the team further insight to focus on a more complete and robust collection of modeling parameters and approaches. SoCalGas intends to use the model as a guide to determine the amount of strain on a pipeline due to ground movement.	
114	~~35~~GO82	Review and Evaluation of the Utonomy Smart Regulator, Phase 2 (5.19.k.2)	20200113225859	Gas Operations	System Design & Materials		Materials and Equipment	1/31/2021	1/31/202~~3~~4	$76,644	$291,800	$76,644	$0		Active	$0	SCG $76,644 | OTD Members $215,156	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	• Share/Publish Results • Technlogy & Knowledge Transfer/Training	The objective of this project is to demonstrate the operation and benefits of the Utonomy Smart Regulator (USR) through laboratory testing and field trials. The use of the USR could provide operators with the ability to remotely monitor and control district regulator stations. The project includes both laboratory and field testing with Utonomy as a partner. In 2021, the task of documenting the Products and System Needs Validation and Requirements began. The next steps are to complete the requirements documentation and perform tests at the Fisher Flow Laboratory. An interim report will be prepared after the laboratory testing is complete to determine whether the project should move forward with field trials. This project has potential technical links to company efforts to bring remote monitoring and control to our distribution system. Further, it aligns with the recently published Pipeline and Hazardous Materials Safety Administration Advisory Bulletin titled Pipeline Safety: Overpressure Protection on Low-Pressure Natural Gas Distribution Systems [Docket No. PHMSA–2020–0025]. .	
115	GO83	Revision of the PRCI Hot-tap Model Two Different Base Material (MATR-3-1B)	20201015223439	Gas Operations	System Design & Materials		System Design	8/17/2020	3/31/2024	$19,946	$69,620	$19,946	$0		Active	$0	SCG $19,946.00 | PRCI Members $49,674.00	Reliability and Safety	Mid Stage (TRL 4-6)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to complete the development of the Pipeline Research Council International's (PRCI) Hot Tap Model V5, a thermal analysis model for in-service welding. This project will update version 4.2.1 of the model and software to expand its coverage to include welding of two different materials and to meet current technology standards. Modeling two kinds of metal could enable a clear understanding of the cooling aspect of the different materials. The project team has updated the model and incorporated it into the software. Although the team completed programming during testing, they encountered issues with the software's graphical user interface (GUI). The team is actively working on the challenges, and progress continues. Unfortunately, the GUI issue has delayed project completion, scheduled to be completed in 2022, to the first quarter of 2023. Once the team finishes the GUI, the Hot Tap Model V5 will be available to PRCI members. The updated software will allow SoCalGas and other utilities to predict weld properties better, thereby enhancing the safety and reliability of pipelines.	
116	GO84	RNG Blending Skid Study	2023011114435	Gas Operations	System Design & Materials		Materials and Equipment	11/17/2022	2/28/2025	$400,000	$400,000	$149,032	$250,968	$149,032	Active	$0	SCG $400,000.00 | None $0.00	Safety, Operational Efficiency, and Environmental: Reduced GHG Emissions	Late Stage (TRL 7-9)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to develop a process and skid design supporting new renewable natural gas (RNG) Interconnections in achieving pipeline gas quality specifications per SoCalGas Rule 45. This effort intends to perform a field demonstration to qualify RNG blending equipment and configurations that will 1) meet Rule 45 requirements, 2) maintain existing pipeline integrity requirements, 3) mitigate the risk of allowing substandard gas from entering the pipeline system, 4) help RNG interconnectors provide RNG to SoCalGas, and 5) help SoCalGas meet company goals in accepting more RNG in its pipeline system. The project team will develop a computational fluid dynamics model and validate it via demonstrations and equipment testing to provide results. The project team will deliver the results in a final report that includes experimental data, analysis of data, resemble data, and blending guidelines and recommendations. SoCalGas intends to procure and implement the proven method and plans to allow for blending Rule 45 RNG with pipeline gas before it enters the pipeline system.	
117	~~36~~GO85	Seismic Risk Assessment and Management of Natural Gas Storage and Pipeline Structure (GFO-18-502)(Group 1) - two projects Slate/Berkeley & UCLA	20200109213857	Gas Operations	System Design & Materials		System Design	6/1/2019	~~6/30/2023~~ 5/31/2024	$13,000	$5,207,752	120500	$9,450		Active	$0	SCG $13,000 | CEC $4,940,158 | LBNL $254,594	Reliability, Safety, and Improved Affordability	Late Stage (TRL 7-9)	• Field Demonstration/Validation Testing • Deployment of Results • Share/Publish Results	The CEC awarded two projects under GFO-18-502 Group 1. The projects each develop seismic risk assessment software tools using different risk models. SoCalGas is involved in both projects. The first project was awarded to Slate Geotech and UC Berkeley for the production of an open-source analysis tool that is easily usable by regulators and utilities. The tool will implement updated methodologies for assessment of seismic risk to underground and aboveground natural gas infrastructure. The tool will have the ability to identify areas of highest risk overlaid with population information to help regulators and utilities identify areas of highest risk to prioritize seismic retrofit projects. To date, a Beta version of the tool has been developed and is being tested. SoCalGas provided data and technical expertise for this project. The second project was awarded to UCLA. This project considers four hazards: Earthquake ground shaking, fault displacement, landslides and liquefaction and to develop a comprehensive set of fragility curves for pipelines and develop an open-source risk assessment tool based on probability-based methodology. To date the project is about 75% complete, and several fragility models have been developed. SoCalGas is participating on the TAP for this project. .	
118	~~37~~GO86	Study on changing Accuracy & Variability of Therm zones affecting metering of new gas supplies (M2022-002)	20220422202256	Gas Operations	System Design & Materials		Materials and Equipment	4/22/2022	6/30/2023	$32,640	$367,250	$32,640	$0		Completed	$0	SCG $32,640 | NYSEARCH Members $334,610	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	• Deployment of Results	Blending hydrogen in natural gas and renewable natural gas (RNG) will change gas properties, such as density, viscosity, and energy content. These altered gas properties may affect the flow measurement performance of natural gas flow meters and interfere with meeting the California Public Utilities Commission (CPUC) requirement of ±2% accuracy in gas delivery to customers. The objective of this project is to characterize the impact of varying hydrogen blends with natural gas and RNG on different types of residential and commercial natural gas meters. First, the project will experimentally gather gas property data that is required to calculate a mass flow rate output from a gas flow meter, compare the results with existing equations of state (EOS), and provide recommendations for best practices and setting appropriate values of uncertainties with various EOS. Secondly, the project will evaluate the suitability and integrity of common metering devices by determining measurement errors and trends when hydrogen content varies with natural gas and RNG. The result of these two tasks will be communicated via a final report and will inform gas utilities on how to determine an accurate and repeatable way to measure and bill the energy delivered to their customers with varying gas supplies. .	Hydrogen-Blending Project The project was completed prior to Resolution.
119	GO87	Study on the Impact of Trace Constituents in RNG on Natural Gas Grids and Consumer Appliances (M2020-008)	2020101905536	Gas Operations	System Design & Materials		Gas Composition And Quality - Trace Constituents	1/15/2021	12/31/2024	$71,390	$606,810	$71,390	$0		Active	$0	SCG $71,390.00 | NYSEARCH Members $535,420.00	Environmental: Reduced GHG Emissions and Environmental: Improved Air Quality	Early Stage (TRL 1-3)	New Research Project to Advance TRL; Modification to Regulatory Standards & Policy; Share/Publish Results	The project objective is to study the impact of trace constituents (TCs) in renewable natural gas (RNG) and traditional pipeline gas to address any potential safety or maintenance risks on local distribution company infrastructure and consumer gas appliances. The project will include a literature search and study of all TCs in RNG to identify any gaps and will perform preliminary laboratory testing on those gaps to identify set limits for six TCs of concern. These limits will assist SoCalGas in determining whether RNG specifications need modification. The team will deliver the results in a whitepaper. In 2021, the team modified the scope to include an impact study on critical TC concentrations. The team has completed the literature review, gap analysis, impact study, and testing has started. The testing includes: 1) volume swell testing, 2) visual inspection and dimensions, 3) mass change, 4) Shore D Hardness, and 5) tensile testing. Testing of consumer gas appliances has been delayed due to procurement issues. Presently, the search for a US supplier is still in progress. If the project successfully determines safe TC limits, SoCalGas plans to use the results to request changes in its Rule No. 45, the Standard Renewable Gas Interconnection, which governs business specifications and RNG tariffs.	

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120	~~38~~	~~T&T Component Counterfeit Detection, Two Way Product Communication Using GS1 Standards (8.17.b.4)~~	~~20210824144128~~	~~Gas Operations~~	~~System Design & Materials~~	-	~~Materials and Equipment~~	~~11/1/2021~~	~~7/31/2022~~ 12/31/2023	~~$13,263~~	~~$229,000~~	~~$13,263~~	~~$0~~	-	~~Completed in 2022~~	$0	~~SCG $13,263 | OTD Members $215,737~~	~~Reliability, Safety, and Improved Affordability~~	~~Mid Stage (TRL 4-6)~~	~~• New Research Project to Advance TRL Level • Share/Publish Results~~	~~This project builds upon other research supporting PHMSA's Tracking and Traceability initiatives. The project objective is to develop a process to screen natural gas piping system components for counterfeits and to develop a mobile system software for communicating quality control concerns about piping system components directly to the component manufacturer in near real-time. Components used to construct natural gas delivery systems may pass initial hydro testing, but failures a few years into service have been linked with counterfeit components. The industry needs tools to scrutinize products used in natural gas piping systems to confirm that they are authentic and that the components are supplied with quality control test reports that are representative of the components received for use. Deliverables for this project include: (1) a Final Report documenting the system, (2) a prototype demonstration of the systems' ability to detect counterfeit components with map-based reporting program, and (3) a narrative of the requirements to deploy the system for commercial operation. The project kick-off is scheduled for early 2022.~~ -	-
121	~~39~~GO88	Universal Analytical Technique for Siloxane - Phase 2 (7.16.g.2)	20191007194636	Gas Operations	System Design & Materials	-	Gas Composition And Quality	5/1/2019	~~4/30/2023~~ 12/31/2024	$49,608	$253,000	$49,608	$0	-	Active	$0	SCG $49,608 | OTD Members $203,392	Reliability, Safety, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	• Modification Regulatory; Standard & Policy • Share/Publish Results	The objective of this project is to develop a universal, industry-wide sampling and analysis procedure for measuring the presence of siloxanes in biomethane. The project team is developing this procedure in collaboration with the American Society for Testing and Materials (ASTM) Committee on Gaseous Fuels. In Phase 1, the team developed and published the ASTM Standard D8230 for the Measurement of Volatile Silicon-Containing Compounds in a Gaseous Fuel Sample Using Gas Chromatography with Spectroscopic Detection. ASTM requires that an Interlaboratory Study Program (ILS) be performed within five years of the procedure publication date. In Phase 2, the team will complete the ILS and field-test an online siloxane analyzer. In 2021, the scope of work was expanded to include a second field site for Pipeline Research Council International's research project, MEAS-15-04. The team will collect periodic grab samples during the testing period for analysis at laboratories following ASTM D8230 procedures to compare the on-line data to data produced using off-line analytical techniques. In 2021, the team continued the ASTM D8230 inter-laboratory study by: finalizing details on the laboratory participation list for the ILS and continuing to plan field evaluations. .	
122	GO89	Updating Lost and Unaccounted-For (LUAF) Estimates in the Distribution System (5.23.t)	2023082223936	Gas Operations	System Design & Materials	-	Materials and Equipment	12/1/2023	8/31/2025	$55,884	$230,000	$0	$55,884	-	Active	$0	SCG $55,884.00 | OTD Members $174,116.00	Safety, Improved Affordability	Mid Stage (TRL 4-6)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	he objective of this project is to update the factors that contribute to the lost and unaccounted-for (LUAF) gas volume in a natural gas distribution system and apply the factors to a case study with participating utilities based on estimates of fugitive and vented emissions, meter readings and characteristics, and other contributing factors. The original study on determining LUAF gas volumes was performed by the Pacific Gas & Electric Company and SoCalGas in the early 1990's (GRI reports 90/0067 and 93/0115). Estimating the contribution of gas leaks supports emissions reporting and more efficiently directs resources to address causes. More accurate estimates of LUAF gas result in better inventory planning, which saves the supply costs. The project outcome will provide a clearer understanding of the current causes of annual gas volume variabilities and help reduce LUAF gas volumes. The project team will provide a final report that includes: 1) the description of the case study process, data collected, and general findings; and 2) quantification of the effects of different sources (i.e., measurement, leakage, accounting, and theft) of LUAF gas and identification of areas of concern or improvement. If the final report precisely identifies the current contribution of the accounting and theft components of LUAF and identifies ways to reduce their contributions to LUAF in the future, then SoCalGas would implement the identified areas of improvement to reduce the area's contribution to LUAF.	
123	~~40~~GO90	Advanced Through-Tubing Casing Inspection for UGS Wells (US-4-04)	20210916213947	Gas Operations	System Inspection & Monitoring	-	Pipeline Systems Inspection Technologies	9/30/2021	~~9/30/2024~~ 3/14/2025	$272,473	$1,760,777	$72,473	$200,000	-	Active	$0	SCG $272,473 | PRCI Members $630,535 | PHMSA $788,594 | Others $69,175	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	• Field Demonstration/Validation Testing • Share/Publish Results	The objective is to advance the sensor technology in through-tubing inspection tools' ability to detect, measure, and characterize metal loss features. This project is looking to work with PRCI to offer a Multi-String Well Integrity Platform that provides a circumferential measurement of corrosion and isolation of external casing strings. The proposed solution will be a fully combinable, advanced sensor technology. The combo will be capable of acquiring data in a single run without pulling out the production tubing. The development of this technological advancement will significantly save UGS operators time and cost by providing the means to evaluate well integrity and effectively plan well intervention activities. SoCalGas would utilize the results to manage well integrity as outlined in each fields Storage Risk Management Plan. The project kick-off meeting was held in November 2021 highlighting the general project objectives, work scope, schedule and responsibilities. The overall project execution plan and regular project meeting schedule were also discussed. SoCalGas would utilize the results to manage well integrity as outlined in each fields Storage Risk Management Plan. .	
124	GO91	Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends (7.23.f)	202211232159	Gas Operations	System Inspection & Monitoring	-	Pipeline Monitoring Systems (Sensors)	12/1/2022	12/31/2025	$87,896	$1,562,946	$87,896	$0	-	Active	$0	SCG $87,896.00 | OTD Members $350,604.00 | PHMSA $749,446.00 | Other $375,000.00	Safety	Mid Stage (TRL 4-6)	Share/Publish Results	This project aims to understand and advance leak-sensing technologies to detect hydrogen (H2) and natural gas (NG) blends as utilities move towards cleaner gas. Ensuring that leaks are detected quickly and efficiently, mitigating the potential harm caused by undetected leaks, and minimizing misinterpreted leak detection results can reinforce safety as the need for new leak detection sensing schemes for H2 and H2/NG blends increases. The project team, consisting of GTI Energy and SENSIT Technologies, will perform the following tasks: 1) evaluate leak detection equipment currently used by NG pipeline operators; 2) guide new and altered usage protocols; 3) validate the H2 blending threshold at which these devices become ineffective; 4) quantitatively map out the impact of varying amounts of H2 on the calibration and analytics of currently used leak detection equipment, and 5) develop a proof-of-concept H2 detection scheme to remedy technology gaps. Upon completion, the project team will deliver new leak detection sensing schemes, ten detailed statistical analyses of laboratory and field testing, an OTD and PHMSA confidential report, a public paper, and a conference presentation. The results from the literature review, leak detection methodology, and sensing specifications could benefit SoCalGas in refining company leak detection policies.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) Project results will support the hydrogen blending pilot projects. SoCalGas will hosting a field demonstration to help validate potential technologies. 2) Testing and influencing developing leak technologies that support the planning and execution of the hydrogen blending demonstartion projects. This could influence PHMSA (federal codes/regulations) when evaluating technologies for monitoring and surveying systems with hydrogen and blends. SoCalGas has requested the use of clean renewable hydrogen to be included this projects scope. The project completed some testing prior to the resolution.
125	GO92	Aerial Methane Monitoring of High-Pressure Distribution System	2023011723722	Gas Operations	System Inspection & Monitoring	-	Pipeline Systems Inspection Technologies	12/14/2022	1/31/2024	$16,369	$16,369	$16,369	$0	$16,369	Active	$0	SCG $16369.00 | None $0.00	Safety and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Technology & Knowledge Transfer/Training	This project aims to conduct and perform a comparative analysis between SoCalGas' current mobile leak survey practice and an aerial-based survey (AMM GML) for high-pressure distribution supply lines. Additionally, it will evaluate the potential operational cost savings associated with utilizing an aerial-based survey for these infrastructure segments. Natural gas transmission lines are tightly regulated, and monitoring transmission pipelines more efficiently and effectively to reduce emissions is crucial for meeting regulatory requirements and SoCalGas safety and environmental goals. The team will simultaneously conduct mobile and aerial-based surveys along 10 miles of a high-pressure distribution main in increments of 1-mile segments. Using an aerial-based survey for high-pressure distribution lines can significantly reduce the time required to survey these assets while also reducing the cost of purchasing, maintaining, and operating mobile-based equipment on fleet vehicles and the number of personnel needed to handle them. Aerial-based surveys could eliminate slower manual tasks and minimize or prevent hazardous, adverse conditions around resources. SoCalGas will utilize the study's results to evaluate potential operational cost savings associated with switching to an aerial-based survey for high-pressure distribution supply line infrastructure segments.	-
126	GO93	Airborne Automated Threat Detection System-Monitoring and Surveillance of Imminent Threats Through Remote Sensing (ROW-3-1&A)	2018112659	Gas Operations	System Inspection & Monitoring	-	GeoHazard Threat Inspection and Monitoring	11/30/2018	12/11/2023	$10,982	$377,683	$10,982	$0	-	Completed	$0	SCG $10,982.00 | PRCI Members $366,701.00	Reliability and Safety	Late Stage (TRL 7-9)	Further Technology Development/Prototype; Field Demonstration/Validation Testing; Commercialization; Technology & Knowledge Transfer/Training;	The project's goals are to develop, demonstrate, and validate automated pipeline patrol and surveillance technologies on an aircraft platform to enhance the detection of third-party activities, ground movement, and other interference that poses risks to pipeline infrastructure. The project team generated data from multiple sensors deployed on aerial patrolto assess the capabilities and limitations of the airborne sensing systems for automated pipeline patrol. The project team made significant progress in validating the performance of an automated Right-Of-Way (ROW) monitoring and surveillance system, operating on long-range, long-endurance, and Beyond Visual Line of Sight (BVLOS) unmanned aircraft. The team gathered data through remote sensing in near-real time. In 2022, a Computing Environment System was developed to support flood detection at river crossings and other threat sources (fires, logging, etc.). Additionally, it supports a proof of concept for detecting liquid hydrocarbon leaks using changes in vegetative health. The final report for the PHMSA co-funded portion of the project was published. The final flight campaign is scheduled for Q4 of 2022. It will be conducted over a pipeline corridor testing the InstiMaps Gen-4 system in a conventional aircraft and BVLOS in an unmanned aerial aircraft. Once the final flight is completed and the results analyzed, the PRCI Final Report will be prepared and submitted to sponsors for review and approval. The results of this project will provide pipeline operators with performance data and information on the capabilities and limitations of airborne sensing systems for automated pipeline patrol to improve surveillance of pipeline ROW corridors.	-
127	~~41~~GO94	Alternate Crack Sensor (M2016-004 Ph IV)	164411262	Gas Operations	System Inspection & Monitoring	-	Pipeline Systems Inspection Technologies	8/9/2021	~~2/28/2023~~ 11/28/2023	$70,190	$491,324	$70,190	$0	-	Completed	$0	SCG $70,190 | NYSEARCH Members $421,134	Reliability and Safety	Mid Stage (TRL 4-6)	• Field Demonstration/Validation Testing • Commercialization	The project team developed and commercialized a sensor probe system for crack detection in longitudinal seam welds (SWs) in 20"-26" diameter natural gas pipelines. In Phase 1, the team developed a concept to integrate the crack sensor probe with the Explorer robotic inspection platform. The concept used two probes: one for finding SWs and one for scanning for cracks. In Phase 2, a prototype was built and field-tested. The sensor successfully identified cracks in all SWs except for electric resistance welds (ERWs). In Phase 3, mechanical designs were refined to improve weld sensor ride and data quality, especially over protruding SWs. Further, the ERW SW detection was improved, such that the data proved consistent and accurate when detecting girth SWs, allowing a smooth operation of orientation transitions between pipeline segments. Data Analysis Tools were improved through testing and fine-tuning the integration of the weld sensor data to the analysis software. At the completion of Phase 3, sponsors elected to continue onto a Phase 4 where the focus is to improve the existing system (developed in Phase 1-3 of this program) with revisions to the mechanical design, weld detection capability and integrations with the Explorer 20/26 robot and operation. The deliverables are to be a revised circumferential MFL sensing system able to detect long SW anomalies as documented in the early phases, an alternative sensor probe for improving detection of low signature long SW, and established specifications of operation. Phase 4 kicked off in August 2021 and began testing to increase the sensitivity of the weld and material detection and modifications to the sensor housing to reduce the weight were made. .	
128	~~42~~GO95	Database of All Burst Tests for Corrosion, Cracking, Dent, and Interacting Defects (EC-2-11)	20211208175940	Gas Operations	System Inspection & Monitoring	-	Pipeline Systems Inspection Technologies	11/19/2021	~~5/31/2023~~ 9/13/2023	$8,780	$147,500	$8,780	$0	-	Completed	$0	SCG $8,780 | PRCI Members $138,720	Safety	Mid Stage (TRL 4-6)	• Modification to Regulator; Policy & Standards • Share/Publish Results	The objective of this project is to develop and populate a database of burst tests for corrosion, cracking, dent, and interacting defects including fatigue tests. To validate improvement in defect assessment or modelling, burst tests and fatigue tests are usually done. These tests are time consuming and expensive, and finding the appropriate pipe samples for testing is also challenging. The project would develop a uniform format for burst test data collection and support future defect assessment and modeling efforts. The benefit of this project is to provide consistent and relevant data for future Pipeline Research Council International (PRCI) studies in defect assessment and growth modelling. The outcome is a database of burst tests and fatigue tests with open access to members. .	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
129	~~43~~GO96	Develop guideline for API 1163 for Inspections Qualification for Level 1, 2, and 3 (IM-1-06)	20220427214251	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	3/25/2022	3/25/2023	$6,313	$154,000	$6,313	~~6313~~ $0	_	Completed	$0	SCG $6,313 | PRCI Members $147,687	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	• Deployment of Results • Share/Publish Results	API Standard 1163 provides requirements for qualification of in-line inspection (ILI) systems. The standard covers the selection, reporting, verification, and three levels of validation associated with in-line inspection systems. The standard also outlines the complexity and cost increase with each level of validation. This project will develop guidelines and procedures for utilities to implement the three levels of validation as prescribed in API 1163 in the qualification and validation of tools for inspection. The emphasis of the project is on developing guidelines and statistical methods to be used for level 1, 2 and 3 analyses. The project will also develop software for level 2 and 3 analyses. The results of this project will help utilities in determining and selecting the validation level that will optimize integrity management resources and reduce overall risk. Ratepayers will benefit from safer and more cost-effective pipeline operations. SoCalGas sponsors this project so that Integrity Management can improve its guidelines describing when level 1, 2 and 3 validation levels are applicable. Integrity Management is particularly interested in defining when a Level 1 validation can be used on pipelines, especially when insufficient anomalies are available for excavation to conduct a level 2 validation. In lieu of excavating anomalies to perform a level 2 validation, a Level 1 validation uses statistical analysis to validate the performance of the ILI tool.	
130	GO97	Downhole Inspection Tool Performance Evaluation	202301041945	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	1/8/2022	5/31/2024	$2,092,939	$2,092,939	$1,907,939	$185,000	$1,495,432	Active	$0	SCG $2,092,938.66 | None $0.00	Reliability and Safety	Late Stage (TRL 7-9)	New Research Project to Advance TRL; Field Demonstration/Validation Testing	The objective of this project is to enhance SoCalGas's (SCG) understanding of new downhole inspection tools used to assess the integrity of gas storage well casing and tubing. Inspection tools will be tested by running them inside fabricated tubing and casing pipe with manufactured anomalies. The measured inspection results will be compared with the known anomaly dimensions to evaluate inspection tool performance and accuracy, i.e., "pull testing." A greater understanding of downhole inspection tool performance will enhance future integrity assessments of gas storage well casing and tubing. In 2022, proof of concept work was completed for a novel high-resolution ultrasonic thickness (UT) inspection tool. The tool was run in four gas storage wells, and its results compared well to established UT and magnetic flux leakage tools. The high-resolution UT tool has been added to the list of tools to be pull-tested. In preparation for upcoming pull testing, tubing and casing were fabricated with manufactured anomalies of known dimensions. In 2023, SCG plans to conduct the pull testing and analyze the results. Through this research, SCG will gain a better understanding of new inspection tool performance and limitations.	_
131	GO98	Eclipse Scientific Red/Green Light Tool for NDE of PE Pipe Butt Fusion Joints - Phase 1-a (M2019-010)	20200102235619	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	1/31/2020	3/31/2023	$13,670	$153,790	$12,000	$1,670	_	Completed	$0	SCG $13,670.00 | NYSEARCH Members $140,120.00	Reliability, Safety, and Improved Affordability	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	Pipefusers can join polyethylene (PE) pipes by melting both ends and forcing the ends together to form a butt-fusion (BF) joint. The integrity of the BF joint is important for long-term performance. This project will develop an automated non-destructive examination (NDE) tool to inspect the integrity of BF joints which does not require operators with specialized training in NDE. NYSEARCH members have invested considerable resources into NDE development for PE pipe through extensive testing with The Welding Institute. Eclipse Scientific has developed the automated NDE constructs of pass/fail (green/red) for performing PE joint pipe interrogation. This project received a portion of the defected BF joint samples developed under the M2019-009 project and completed all the scans of PE pipe standard and defect pipe to continue the integration of automated defect recognition within NDE pass/fail (green/red) characterization. In 2022, additional samples were shipped to the project team to continue the scan of defective samples building the dataset. Artificial Intelligence will use the library of scanned standard and defect pipe samples and the acceptance criteria to base NDE decisions. These scans provide the basis for automated anomaly identification and interrogation of deciding on a pass/fail during an NDE PE pipe inspection. The project team will provide the final report summarizing the tool's performance at the end of the project. The development of this technology will improve the integrity of BF joints constructed by SoCalGas since any defect in the joint would be identified before placing the pipe into service.	_
132	~~44~~GO99	Electromagnetic Time Domain Reflectometry (EM-TDR) for Pipeline Integrity (M2021-004 Ph I)	2021052765423	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	5/1/2021	~~5/31/2023~~ 3/29/2024	$28,850	$339,000	$28,850	$0	_	Active	$0	SCG $28,850 | NYSEARCH Members $310,150	Reliability and Safety	Early Stage (TRL 1-3)	• New Research Project to Advance TRL Level • Further Technology Development/Prototype	Electromagnetic Time Domain Reflectometry (EM-TDR) is a mature technique developed to identify and locate faults in metallic cables. Lawrence Berkeley National Lab (LBNL) proposes to adopt the EM-TDR technique to the inspection of transmission natural gas pipelines. Variations in materials and pipeline geometry have a significant effect on this technique's performance and tuning. This project will evaluate method feasibility for the intended application, and if successful, it will lead to additional phases to develop and test an engineering prototype, a pre-commercial protype and ultimately result in commercialization. This technology would allow for SoCalGas to obtain more information on difficult- to -access portions of pipelines that are currently assessed by External Corrosion Direct Assessment (ECDA). If this tool is applicable to pipelines as outlined in the proposal, EM-TDR could be used to provide further assessment of carrier pipe within cased segments, as well as other crossings where ECDA techniques are not available. This tool would be used to supplement and enhance existing ECDA inspection techniques.	
133	GO100	Energy Harvesting in Gas Industry Applications (M2016-006) - Phase I/II	20191003213535	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	12/1/2016	5/19/2023	$27,931	$293,235	$18,931	$9,000	_	Completed	$0	SCG $27,931.00 | NYSEARCH Members $265,304.00	Reliability, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL,Further Technology Development/Prototype; Field Demonstration/Validation Testing	The project aims to conduct a feasibility study to identify technologies that generate 3-5 watts of power by harvesting energy from available "background" resources (e.g., vibration, flow, temperature differences, etc.). This effort will provide power to sensory and related devices in areas where utility power is limited or non-existent and remove the need for replacing batteries. In Phase I, the team initiated a feasibility study to determine if energy harvesting using the energy available in the system's environment could be converted to power and identified four potential technologies: (1) vibration energy, (2) fuel cell energy, (3) thermal energy, and (4) fluid flow energy. In phase II, the team will evaluate the technologies for practicality and commercial availability. In 2022, the project team looked at two energy harvesters, the thermoelectric generator and the electrodynamic turbine generator. Field testing was performed in Q4 2022 using a 20-watt thermoelectric generator to convert heat energy from gas burning into electricity and for the electrodynamic turbine generator. Analysis of the test results is in progress, with the Final Report scheduled for release to sponsors in Q1 2023. Once the team completes the project, SoCalGas will analyze and review the results to determine if they should further study the equipment for operations.	_
134	GO101	Explorer Automation Demonstration	20230817185327	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	12/1/2023	12/31/2025	$800,000	$800,000	$0	$800,000	_	Active	$0	SCG $800,000.00	Reliability,Operational Efficiency, and Improved Affordability	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results; Technology & Knowledge Transfer/Training	The objective of this research is to support Integrity Management to field test a pipe explorer in-line inspection (ILI) tool. This ILI tool is an improvement to traditional inspection robotic platforms. The tool is a wireless-self-propelled inspection tool used for traditional and unpiggable steel pipe inspection. The automatic explorer features wireless in-line charging, new metal loss and deformation sensors, axially orientated to target crack-like features on or near long seam weld and can maneuver through back-to-back elbows at 45°/90° mitered bends. The ILI tool will be demonstrated at one of SoCalGas' 30-inch transmission line. In 2023, the project team discussed and submitted feedback to the Master Service Agreement between SoCalGas and the vendor. The demonstration is scheduled to begin in early 2025. SoCalGas can use this research to add to the list of tools to identify features for integrity management which will benefit ratepayers by augmenting operational efficiency, reliability, and improved affordability.	
135	GO102	Explorer Wireless Range Extender (M2021-006 Ph II)	2022042218954	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	4/22/2022	5/31/2024	$83,240	$736,788	$59,675	$0	$23,565	Active	$0	SCG $59,675.00 | NYSEARCH Members $482,725.00	Reliability, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Commercialization; Share/Publish Results	This project builds on Phase I, in which the project team performed a feasibility study for extending the wireless communication range of the existing Explorer In-Line inspection robot while deployed in the gas pipeline. The project team will implement the recommendations from Phase I and develop a prototype that can be demonstrated in the gas infrastructure. This project consists of six tasks: 1) Concept Review and Detailed Design, 2) Manufacturing and Assembly, 3) Full System Testing, 4) Investigation of Implementation in Other Robot Sizes, 5) Communication Protocol Enhancements, and 6) the Final Report. In 2022, a feasibility study was completed and reported that a significant communication range extension is possible with combinations of wireless technologies and in-pipe antenna deployment via range extender modules (REM). The update to the mechanical design to fit within a 15-inch diameter, meet weight requirements, and provide a more robust and efficient system, is 80% complete. The electrical design is finished. The next steps will finalize the coding and design of the firmware, graphical user interface, mechanical drawings, procurement of mechanical parts, assembly, and testing. The project deliverable will be a report and a prototype that can be commercialized. SoCalGas will benefit from this project by using the commercialized prototype to increase the efficiency of its pipeline inspection and reduce the overall inspection cost.	_
136	GO103	Extending Energy Harvesting to Other Explorer Sizes - A Feasibility Study (M2021-011)	2021110821722	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	11/15/2021	5/31/2026	$19,395	$193,948	$19,395	$0	_	Active	$0	SCG $19,395.00 | NYSEARCH Members $174,553.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing; Commercialization; Share/Publish Results	The objective of this project is to perform a feasibility study on the scalability of the Explorer 20/26 Energy Harvesting (EH) system, equipped to function within 20" and 26" diameter pipe, to other platforms and specifically to determine the performance envelope for the Explorer 10/14, 16/18, and 30/36, within 10" and 14", 16" and 18", and 30" and 36" diameter pipe, respectively. This project consists of five tasks: 1) the team will perform an analysis on the robot to determine its power consumption under various operational conditions and the energy and tow force that can be generated for the robot within different pipe sizes; 2) the team will investigate the mechanical design of the EH system and its impact on the overall weight of the robot; 3) & 4) the team will evaluate the amount of power and energy generated for different pipe sizes under different operating conditions, and they will modify the EH system's electronics, if necessary; and 5) will explore the potential impacts of the EH technology in its commercial deployment across various Explorer robot platforms. The team will deliver a report outlining the tasks conducted during the feasibility study, including 1) the key parameters for an EH system for different pipe sizes of the Explorer fleet; 2) remedying technical obstacles that EH systems need to overcome to be successfully developed in future phases, and 3) recommendations on the next steps. The project kicked off in May 2022 but is currently on hold until 2023 due to resource constraints. This project, if successful, will expand the inspection capabilities of the Explorer robotic tools and allow the SoCalGas in-line inspection (ILI) program to collect more data and conduct longer inspections.	_
137	GO104	Ground Cover Change Detection for Transmission Pipelines (8.23.k)	2020022743825	Gas Operations	System Inspection & Monitoring	_	GeoHazard Threat Inspection and Monitoring	12/1/2023	3/31/2025	$53,100	$190,000	$0	$53,100	_	Active	$0	SCG $48,100.00 | OTD Members $136,900.00	Reliability, Safety, Operational Efficiency	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Deployment of Results	The objectives of this project are to evaluate existing manual, time-consuming, and costly processes for monitoring pipelines and to automate the processes for identifying threats around transmission pipelines. The project will identify cost-effective modern technologies and methodologies that may enhance the monitoring of critical assets and help identify previously undetected threats. The project team held a kick-off meeting and determined the project would address weather-related outside forces in ground cover detection for potential landslide, erosion, and change detection of pipeline crossing agriculture land. The project team conducted the project scoping and developed the research methodology to focus on short-range (instrument attached to a vehicle) and remote (satellite) detection technologies. The next step is to perform market research of commercially available technologies for ground coverage change detection, object detection, and other similar use cases that might have applications for transmission pipeline monitoring. The project deliverables include: 1) project scoping, 2) market research, 3) lab testing, 4) a field demonstration within SoCalGas territory, and 5) a final report. Identifying processes that simplify and improve these monitoring activities will improve the safety, reliability, and cost-effectiveness of our operations. SoCalGas will use this research to improve processes that could aid in identifying threat areas caused by potential mechanical damage and weather-related outside forces.	
138	GO105	Hard Spot Detection (MAT-7-2A)	20230908215351	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	12/1/2023	5/31/2025	$15,000	$900,000	$0	$15,000	_	Active	$0	SCG $15,000 | PRCI Members $885,000	Reliability and Safety	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results	The objective of this project is to assess various inline inspection (ILI) tools to help operators streamline hard-to-detect hard spots. Hard spots are areas on the pipe with hardness levels higher than the surrounding pipe. Hard spots are locations that can be more susceptible to cracking mechanisms such as bending strain and corrosion. In pipelines with blended gas, any internal abnormality initiated at a hard spot could likely grow as hydrogen is a smaller molecule compared to methane. This occurrence has the potential for hydrogen seepage, which is known to affect material integrity. ILI tools that can identify hard spots, as well as recognize metallurgical properties, grade determination, and fracture behavior are important elements to any integrity program. SoCalGas anticipates using the results of this project for guidance on identifying pipeline segments with susceptibility to hard spots, assessing the effectiveness of commercially available hard spot detection tools, evaluating the potential impact of cathodic protection on hard spots, and providing information that could improve the management and response criteria.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
139	GO106	High Resolution MFL for Explorer Series of Robotic Platforms - Feasibility Study (M2021-009)	20211108181931	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/15/2021	8/1/2024	$23,900	$215,084	$23,900	$0		Active	$0	SCG $23,900.00 | NYSEARCH Members $191,184.00	Safety and Operational Efficiency	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; Further Technology Development/Prototype; Share/Publish Results	The objective of this project is to do a feasibility study on integrating a high-resolution magnetic flux leakage (MFL) sensor onto the Explorer robot platform, assess multiple commercially available sensors, and optimize the resulting system for maximum efficiency and interchangeability among the various robots. This project has four tasks: 1) determine the best sensor for the application while considering potential solutions to implementation issues (i.e., sensor control, data transfer); 2) identify various concepts for sensor positioning and design schemes, and select the best one; 3) build a benchtop prototype system based on the design selected in Task 2 to validate optimal integration into the magnetic bars and performance (data collection and transfer, sensor resolution, defect sizing resolution, etc.); and 4) summarize the results with a recommendation for implementing the new sensors on the MFL module. The project was kicked off in early 2022, but due to resource constraints, the tasks will begin in early 2023. The next step will be to complete a feasibility study and then build and test the proof-of-concept prototype. The team will deliver a benchtop prototype system along with a feasibility analysis report and recommendations on the next steps. Improving the sensor capabilities of the Explorer family of robotic platforms will be of benefit to the SoCalGas In-line Inspection program because the smaller sensors will allow for higher spatial and circumferential resolution and detectability of smaller defects with higher resolution, therefore, allowing higher confidence levels in the measurements made.	
140	GO107	ILI-Based Generic External Corrosion Growth Rate Distribution for Buried Pipelines (EC-01-13)	202105071759	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	6/23/2021	12/15/2023	$19,308	$193,662	$19,308	$0		Completed	$0	SCG $19,308.00 | PRCI Members $174,354.00	Reliability and Safety	Mid Stage (TRL 4-6)	New Research Project to Advance TRL,	The goal of this project is to provide the industry with generalized in-line inspection (ILI) based corrosion growth rate distributions and associated causal factors. The distributions will be based on actual data from successive ILI runs provided by Pipeline Research Council International members. The project will develop a probabilistic model for estimating external corrosion growth (ECG) rates via successive ILI runs. The team will analyze in-the-ditch inspection data to determine statistical corrosion depth distributions. They will also perform a literature review for various ECG rate estimation strategies, which will help them decide if any existing models can be utilized. In 2022, the project team collected ILI data from sponsors to refine the Bayesian Network variables. The project team continues to implement key parameters in updating the Multi-Analytic Risk Management (MARVTM) tool, a Bayesian Network approach for statistically quantifying risk and corrosion growth. The software is already developed, but the team will refine it during this project based on recent industry work and input from industry subject matter experts. Local distribution companies will continue to develop and refine the ECG rate probability curves. A better understanding of ECG rates along the pipeline could result in more accurate reassessment intervals, allowing member companies to optimize ILIs for metal loss. SoCalGas will utilize the research study's applicability in increasing the accuracy of ECG rate calculations to determine the remaining life of the pipeline. After evaluation, SoCalGas could benefit from this research by potentially integrating the deliverables into the company-specific Transmission Integrity Management Program.	
141	GO108	Improve ILI Sizing Accuracy (PHMSA) (NDE-4-19)	20200203203815	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	9/30/2019	6/30/2023	$5,000	$2,251,100	$5,000	$0		Completed	$0	SCG $5,000.00 | PRCI Members $605,923.00 | PHMSA $725,000.00 | Technology Providers $725,000.00	Reliability and Safety	Mid Stage (TRL 4-6)	Further Technology Development/Prototype; Technology & Knowledge Transfer/Training;	The goal of this project is to understand the probability of detection by state-of-the-art In-Line Inspection (ILI) tools for internal anomalies in steel pipes. It is important to understand the likelihood of identifying abnormalities in the steel pipe as it 1) can minimize the number of missed defects without increasing the number of false indications, 2) optimize the number of excavations needed for operation pipeline safety, and 3) allow for more efficient utilization of resources. Research outcomes will improve ILI sizing accuracy of cracking, crack-like anomalies, and corrosion anomalies and allow ILI technology developers to improve and adjust sizing algorithms for these anomalies. In addition, developers can re-run tools on test strings with modified sensors, sensor configurations, and sizing algorithms. In December 2021, the ILI Technology Providers completed the delivery of the ILI reports for the initial (blind) test. In 2022, they were asked to detect and characterize a blind set of metal loss anomalies and evaluate detection, identification, and sizing capabilities for each defect type. The ILI performance evaluation and data verifications are in progress, and providers are currently comparing truth data to ILI results. PHMSA has granted a time extension for the project due to extended vendor timeframes for data processing and improvement analysis, and reporting with potential retesting. SoCalGas can use this research to improve ILI vendors' sizing accuracy, which will benefit in targeted excavations toward potentially immediate conditions.	
142	GO109	INGAA - Geohazard Management JIP	20220719234857	Gas Operations	System Inspection & Monitoring		GeoHazard Threat Inspection and Monitoring	7/18/2022	9/26/2023	$37,996	$562,996	$37,996	$0		Completed	$0	SCG $37,996.00 | JIP Members $525,000.00	Reliability and Safety	Late Stage (TRL 7-9)	Modification to Regulatory Policy & Standards; Share/Publish Results	The objective of this project is to provide a high-level, concise framework for pipeline operators to utilize in managing geohazards considering no best practices or recommended procedures for geohazard data management currently exist. This set of documents will include a detailed recommended practice (RP) and a guide for implementing and executing a geohazard land movement management program. A secondary goal is to support potential rulemaking by the Pipeline and Hazardous Materials Safety Administration (PHMSA) related to geohazard management. The project team will produce a published RP by the American Petroleum Institute (API). The team has reviewed various PHSMA and European data sets addressing gas and liquid incidents caused by Weather-Related Outside Forces and interviewed sponsors about their geohazard integrity management programs. Additionally, the project team is working on a high-level framework paper for geohazard management with an expected completion date in January 2023. A second paper will provide an RP for landslide integrity management, with expected completion in March 2023, and will likely be added to API RP 1187. The team reviewed both draft papers with comments in November 2022. Upon completion, the aforementioned documents could aid SoCalGas with its geohazard management framework and landslide threat evaluations.	
143	GO110	Innovative Leak Detection Methods for	202211113941	Gas Operations	System Inspection & Monitoring		Data Analytics	9/29/2022	9/28/2025	$13,393	$547,226	$13,393	$0		Active	$0	SCG $13,393.00 | PRCI Members, PHMSA $533,833.00	Safety, Improved Affordability, and Environmental: Reduced GHG Emissions	Mid Stage (TRL 4-6)	Deployment of Results	The objective of this project is to develop 1) improved algorithms to estimate pipeline inventories lacking full pipeline transient modeling applications, 2) a new algorithm for enhanced zone balancing calculations, 3) pattern identification methods that identify how corrected zone balances shift due to changes in system flow, which the project team will use to identify meters that are most likely attributing to measurement flow errors, and 4) recommended practices to troubleshoot facilities with high error probabilities. Computational pipeline monitoring (CPM) systems have technology gaps. For example, 1) balancing zones are minimal in number and encompass too large areas, 2) retrofitted inline flow measurement systems are difficult to install, 3) challenges faced with changes in gas pipeline systems inventory or distinguishing measurement errors from leaks, and 4) unavailable, infrequent, or asynchronous data. Addressing these gaps will enhance CPM leak detection methods by detecting and locating leaks more accurately and quickly. The project team will test the developed algorithms and methods on simulated systems and then validate them on a gas pipeline system. This research could reduce 1) lost, and unaccounted-for volumes of gas, 2) impacts on safety, and 3) impacts on the environment. The results will be presented in a final report and at a public forum. The developed algorithms and methods could be used in SoCalGas measurement accounting systems if successful and compatible.	
144	GO111	Internal Corrosion Management	2023011722739	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/17/2022	11/30/2023	$88,833	$88,833	$88,833	$0	$88,833	Completed	$0	SCG $88,833 | None $0.00	Reliability and Safety	Early Stage (TRL 1-3)	Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to review existing processes and data associated with "potentially corrosive constituents" as identified in 49 C.F.R. § 192.478 to evaluate whether changes should be implemented to comply with recent federal regulations. Potentially corrosive constituents include, but are not limited to: carbon dioxide, hydrogen sulfide, sulfur, microbes, and liquid water. In task 1, the project team will review SoCalGas procedures. In task 2, the project team will create a flow diagram for the data currently being collected. The project deliverables will include a report identifying next steps, such as preparing a white paper documenting the known limits for constituents or additional research which needs to be performed.	
145	GO112	Low Flow EMAT ILI Tool Demonstration (qi II)	20220214204743	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	11/26/2021	9/30/2024	$225,000	$225,000	$0	$225,000		Active	$0	SCG $225,000.00 | None $0.00	Reliability, Safety, and Operational Efficiency	Late Stage (TRL 7-9)	Deployment of Results; Technology & Knowledge Transfer/Training	The goal of this project is to demonstrate the capabilities of the 12" and 16" free-swimming Electromagnetic Acoustic Transducer (EMAT) tool with a field demonstration inspecting SoCalGas transmission pipelines. Many In-line-Inspection (ILI) technologies use a Magnetic Flux Leakage (MFL) detection method to measure wall loss on metallic pipelines due to internal and external corrosion. Under previous research projects, an EMAT sensor and robotic platform for small-diameter unpiggable pipelines capable of identifying smaller defects than traditional MFL tools were developed for commercialization. Building upon this research, a free-swimming version of the tool has been created. Free-swimming tools are of interest to subject matter experts such that the tools are propelled by the flow of internal pipeline pressures. The demonstration was moved to 2023 to allow Integrity Management to complete a feasibility review of the pipelines. If the demonstration is successful, SoCalGas will have an alternative for performing pipeline inspections on unpiggable pipelines with traditional tools.	
146	GO113	Microbial Influence Corrosion (MIC) Detection (GFO-21-506, Group 2)	20221216173640	Gas Operations	System Inspection & Monitoring		Pipeline Systems Inspection Technologies	10/25/2022	9/30/2026	$75,000	$1,518,920	$38,854	$36,146	$38,854	Active	$0	SCG $75,000.00 | CEC $999,970.00| Others $443,950.00	Reliability, Safety, and Improved Affordability	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish Results; Technology & Knowledge Transfer/Training	The project objective is to develop and pilot a self-contained portable microbial detection kit that will allow fast detection and identification of various corrosion-related microbes from raw samples with minimal hands-on time. Microbial testing is an essential component in detecting, controlling, and mitigating microbiologically influenced corrosion (MIC) in natural gas systems. Current testing approaches are hampered by long wait times, the inability of rapid tests to identify specific corrosion-related microorganisms, and complex sample preparation and testing processes that require laboratory equipment or highly specialized personnel. The team has scheduled the project to begin in February 2023, with field pilot demonstrations performed under various environmental conditions after that. The project deliverables include Test Kit Documentation and a Field-Testing Guide, which will build the foundation for developing new approaches for detecting, monitoring, predicting, and controlling microbial corrosion in California's natural gas pipeline systems. The primary benefit will be the timely detection of specific corrosion-related microbes in pipelines and storage tanks which will provide a basis for developing targeted strategies for the control of microbial corrosion and reduce the use of expensive and environmentally toxic broad-spectrum biocides. SoCalGas intends to use the research and development of the portable microbial detection kit as it will potentially provide a more accessible and lower-cost method to detect and identify the presence of microbiologically influenced corrosion (MIC) in natural gas systems.	
147	GO114	Modernize the Assessment of Pipeline Water Crossings (ENV-4-1A)	2018112166	Gas Operations	System Inspection & Monitoring		GeoHazard Threat Inspection and Monitoring	1/1/2019	4/17/2023	$24,119	$740,035	$24,119	$0		Completed	$0	SCG $24,119.00 | PRCI Members $329,712.00 | PHMSA $386,204.00	Safety and Improved Affordability	Late Stage (TRL 7-9)	Share/Publish Results	The objective of this project is to improve the capabilities of existing streamflow monitoring techniques and engineering and risk assessment tools used for managing the integrity of pipeline crossings over waterways. The project tasks include field verification of scour and erosion prediction from hydrology hydraulics and fluvial geomorphology; field validation of Vortex-Induced Vibration (VIV) initiation within waterways to determine pipeline limitations and VIV avoidance criteria. The goal is to allow operators to identify crossings that require operational (e.g., monitoring) or engineering (e.g., mitigation) controls to lower the probability of flooding hazards that can lead to containment loss. The project team will build and test a prototype website-based alert dashboard. The dashboard could also be a screening tool to plan new waterway crossings. The results of this project can supplement the guidance provided in API RP 1133, Managing Hydrotechnical Hazards for Pipelines Located Onshore or Within Coastal Zone Areas. To date, the project team has delivered nine of nine final reports to PRCI members. Eight are available on the Pipeline Research Council international website. The team anticipates completing the final project report in early 2023. SoCalGas will use this information as a knowledge base for evaluating and maintaining pipeline water crossings.	
148	~~45~~	~~Monitoring Solution for pipeline A/C Interference~~	~~20220207211737~~	~~Gas Operations~~	~~System Inspection & Monitoring~~	-	~~Corrosion Inspection and Monitoring~~	~~12/14/2021~~	~~9/30/2022~~ ~~12/31/2023~~	~~$96,759~~	~~$96,759~~	~~$0~~	~~$96,759~~	-	~~Completed in 2022~~	$0	~~SCG $96,759~~	~~Reliability and Safety~~	~~Late Stage (TRL 7-9)~~	~~• Deployment of Results~~	~~Increasing energy demand has led many electric utilities to increase capacity. In some cases, this can cause AC interference and ground/earth faults, which occur when straying electrical current takes a pathway directly to the ground. This increases risk for buried gas pipelines within shared rights-of-way. These faults can also damage pipeline coatings. Thus, utilities need a wide variety of technologies and methodologies to identify and then mitigate or minimize any AC threats to pipeline integrity. SoCalGas's Integrity Management department is developing an AC interference procedure to identify, monitor, and mitigate this risk on segments along its pipeline. One of the key components in addressing AC interference is identifying powerline loading trends. Unfortunately, powerline load information is not readily available. This project will evaluate and demonstrate a technology that collects powerline load data independent of electrical utilities. The resulting data could support risk analyses to determine if AC interference events occurred and if there is a need for continual monitoring and/or mitigation. In addition, the data collected may be used with the AC PowerTool software developed in the OTD AC Earth Faults project completed earlier in 2021.~~ -	-

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
149	GO115	NDE Tool for Electrofusion Fittings (M2022-004)	20210517163051	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	8/30/2022	3/31/2024	$16,925	$156,575	$16,925	$0	_	Active	$0	SCG $16,925.00 | NYSEARCH Members $139,650.00	Reliability and Safety	Late Stage (TRL 7-9)	Field Demonstration/Validation Testing	Inspecting Polyethylene (PE) Electrofusion (EF) fitting joints is an important quality control check, confirming that the fusion between the pipe and EF fitting has properly formed, ensuring its long-term performance. Currently, inspection is limited to visual observation of the final exterior joint surface due to the EF joint's internal configuration. Without direct observation of each step in preparing the PE pipe and EF fitting, there is no opportunity to assess a final EF joint internal configuration after the fusion between the PE pipe and fitting is complete. However, there are non-destructive evaluation (NDE) methods available to look beyond the outer surfaces of EF PE pipe fusions. This approach provides high granularity inspection capabilities of the joined material between the PE pipe and fitting. These NDE techniques require highly trained and experienced NDE personnel to perform the testing and interpreting of the results. A method of NDE inspection is desired to enable a non-NDE expert to look within the EF joint internally to observe the general configuration, confirming an acceptable fusion has been obtained. The scope of this project is to develop an NDE technique for visual examination of the internals of a PE pipe EF fitting using a digital x-ray. This research will include 1) an NDE digital x-ray and quality control interpretation method, 2) an application for personnel who are non-experts in NDE methods to perform field procedures, and 3) training guidelines for setting up and performing NDE in a safe, effective, and efficient manner. SoCalGas can use this X-ray system in the field to assess PE EF joint quality before installing fused piping in the ground, which would contribute to pipeline safety and integrity.	_
150	GO116	NJIT Advanced Terahertz (THz) Imaging & Spectroscopy for Non-Destructive Evaluation of Polyethylene Pipes (M2018-009 PhII)	20200630224116	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	7/1/2020	3/31/2025	$59,615	$902,581	$42,700	$16,915	_	Active	$0	SCG $59,615.00 | NYSEARCH Members $633,932.00	Reliability and Safety	Late Stage (TRL 7-9)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL; Further Technology Development/Prototype	Technology advancements may be useful in assessing the quality of questionable butt fusion (BF) joints and may prevent unnecessary cutouts of good BF joints with the appearance of a bad fusion. The objective of this research project is to continue the development of terahertz (THz) time-domain spectroscopy and imaging for the nondestructive evaluation (NDE) of PE gas pipeline BF joints. Phase II evaluates the THz capability on BF joint samples with inclusions at the acceptance criteria threshold. The team has performed extensive NDE inspections of specific PE joint defects containing a lack of fusion. The birefringent application to the THz NDE process has advanced with improved inspection procedures and analytical signal processing. In 2022, the project team worked on improving signal resolution using the THz inspection process during scan interpretation to identify potential defects, including "cold" or lack of fusion within the BF. The project team will provide a final report, including the results of technical assessments of THz NDE potential for plastic pipes, at the end of the project.	_
151	GO117	Pipeline Cleaning Tool for Liquids with Flow (M2017-006 Ph II)	20210507142215	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	5/6/2021	8/15/2023	$79,765	$339,000	$79,765	$0	_	Completed	$0	SCG $76,530.00 | NYSEARCH Members $902,581.00	Reliability, Safety, and Operational Efficiency	Mid Stage (TRL 4-6)	Further Technology Development/Prototype; Field Demonstration/Validation Testing; Commercialization	InvoDane will develop and test expanding the capability of the 20/26 Explorer robot, which is capable of inspecting "difficult-to-inspect" pipes while remaining in service, to drive and scan through an accumulated liquid in the natural gas pipelines. When inspection teams find liquids in the pipeline, inspections must stop until they remove the liquids before proceeding with the examination. With regulatory-driven due dates, delays in completing assessments can result in non-compliance. This research, if successful, will allow inspection teams to continue without the need to halt for liquid removal. Pre-commercialized liquid-capable drive tracks and magnet bars will be designed and tested for retrofit onto an Explorer 20/26 robot and included on future-generation robots. In 2022, the project team had the components manufactured, and they completed testing on the magnet bar and drive tracks. The liquid-capable testing of the modules is underway. In early 2023, the project team will perform the final tests to verify the validity of the design. After this project, InvoDane plans to build several sets of liquid-capable drive tracks and magnet bars to incorporate into other robots. SoCalGas could potentially use this new Explorer robot for inspections where there is a risk of liquids in the pipeline improving data quality and inspection performance.	_
152	GO118	Plastic Pipeline Inspection for Pipeline Integrity Management (GFO-22-503)	202309082232	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	12/1/2023	8/18/2026	$15,000	$15,000	$0	$15,000	_	Active	$0	SCG $15,000 | CEC $999,319 | Others $596,394	Operational Efficiency, Improved Affordability, Environmental: Reduced GHG Emissions, and Environmental: Improved Air Quality	Late Stage (TRL 7-9)	Deployment of Results; Share/Publish Results	The objective of this project is to demonstrate the probability of detection of different categories of anomalies in plastic pipe assemblies when using Phased Array Ultrasonic Testing (PAUT) non-destructive evaluation (NDE) tools for inspecting both plastic pipe and fusion joints. The most common modes of material failure for polyethylene piping systems are slow crack growth and non-ductile fusion joint failure, and current NDE methods for plastic piping are not as well developed as they are for steel piping systems. This project will also identify the correlation of expected residual lifetimes for assets, given the indication of defect, by utilizing the information provided by NDE inspections allowing for input into the risk assessment models. The project will focus on extensive testing of a relatively mature PAUT tool capable of identifying cracks in pipe walls and defects in fusion joints. The fieldwork will be supported by extensive laboratory testing aimed at verification of inspection results and accelerated lifetime testing of the pipe assemblies where indications of defects may be identified. If the results are fruitful, SoCalGas will deploy the technology to enhance the safety of plastic pipelines by introducing new NDE inspection tools for both plastic pipe and fusion joints.	
153	GO119	Selective Seam Weld Corrosion Detection with In-line Inspection Technologies (NDE-4-13)	202009282175	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	10/6/2020	6/30/2024	$34,713	$810,000	$34,713	$0	_	Active	$0	SCG $34,713.00 | PRCI Members $775,287.00	Reliability and Safety	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing; Technology & Knowledge Transfer/Training	The objective of this project is to evaluate and validate magnetic flux leakage (MFL) technologies currently in use by In-Line Inspection (ILI) vendors for detecting selective seam weld corrosion (SSWC). SSWC is a type of corrosion that affects the bond-line region and heat-affected zone of the longitudinal seam of a pipeline, forming grooves in the seam. Circumferential MFL technologies can detect the long-seam weld position and accurately detect the presence of corrosion on the long seam. However, these MFL tools generally cannot differentiate between SSWC and coincidental corrosion. As technologies and analysis processes have improved, ILI vendors are now better able to detect SSWC. This project will provide pipeline operators with up-to-date knowledge about ILI capabilities to detect SSWC and differentiate it from coincidental corrosion interacting with the long seam weld. This knowledge will help them make informed decisions about managing pipelines with SSWC or corrosion. In 2022, the vendor completed acid etching to create test samples with SSWC and corrosion. They delivered documentation that addresses raised edges of electrical discharge machined (EDM) notches and adjacent corrosion. SoCalGas can use this research's results and identified tools to detect SSWC in its pipelines better, thereby improving safety and reliability.	_
154	GO120	Sensing Liquid Accumulation in Mains (OTD 5.24.e)	2024012421638	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	12/1/2023	12/1/2024	$20,000	$100,000	$0	$20,000	_	Active	$0	SCG $20,000 | OTD Members $80,000	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	New Research Project to Advance TRL; Further Technology Development/Prototype; Field Demonstration/Validation Testing; Share/Publish results	The objective is to identify non-contacting, level-sensing technology that could be used in natural gas systems to detect liquids. Utilities install drips to collect liquids, so customers are not impacted. A low-cost system is needed to alert the utility of liquids levels in near real-time, and this project is the first step toward this goal. The project team will test and verify the identified sensors in the laboratory. The sensor testing results and a reference design for a field system will be provided that could be incorporated into a remote monitoring system in the project's next phase. The project tasks include: 1) identifying commercially available level-sensing/ranging sensors, 2) bench-testing a selection of the sensors, 3) performing an analysis of the data to determine the accuracy and whether the sensor is a viable option for this use case, and 4) developing a field prototype design for sensor(s) passing testing. SoCalGas is anticipating that the field-deployable sensor system will be demonstrated at its test facility, and, if the test is successful, will be evaluated for possible deployment. The project benefits are expected to be reduced costs and improved reliability of service to ratepayers.	
155	GO121	Subsidence Study	20220720212647	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	11/25/2022	4/28/2023	$17,200	$17,200	$17,200	$0	_	Completed	$0	SCG $17,200.00 | None $0.00	Reliability and Safety	Early Stage (TRL 1-3)	Modification to Regulatory Policy & Standards; Deployment of Results; Share/Publish Results	This project will perform analytical modeling to estimate levels of relative displacement between a transmission pipeline and five tap locations, validating the results of earlier studies. Buried natural gas pipelines can be damaged by soil displacement resulting from sudden extreme events, such as floods, landslides, earthquake fault rupture, and gradual ground deformations caused by land subsidence. Causes of vertical or horizontal land subsidence include extraction of water, oil, or gas; sinkholes; mining activities; and natural consolidation. A previous study evaluated the potential hazard to natural gas transmission pipelines from subsidence resulting from water withdrawal in the San Joaquin Valley. The results supported the conclusion that long-term subsidence from water withdrawal does not pose a significant threat to steel gas transmission pipelines at general locations. However, the study concluded that relative axial displacements at some tap locations could be a concern in the future. The study recommended that efforts be taken to discern if there are signs of relative displacement or distress at tap points identified as having the largest relative axial displacements. The project tasks include modeling a section of transmission pipe and five tap locations and analyzing various scenarios affecting tensile and compressive strain as a function of axial displacement. The team will perform the analyses using simulation software with typical pipe elements and non-linear springs to represent soil restraint. This study could help to pre-emptively manage the subject tap locations and significantly reduce the need for costly mitigative measures to repair or replace damaged pipeline sections due to subsidence displacements.	_
156	~~45~~GO122	Technology Development Center (TDC-1-1 & 1-A)	SCG1540077	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	1/1/2015	12/31/202~~3~~4	$42,709	$3,440,727	~~35351~~ $42709	$7,358	_	Active	$0	SCG $42,709 | PRCI Members $3,398,018	Reliability and Improved Affordability	Late Stage (TRL 7-9)	• Field Demonstration/Validation Testing	This project provides support for the new Pipeline Research Council International Technology Development Center (TDC) in Houston, Texas which opened in the summer of 2015. The TDC is the result of a major commitment by the energy pipeline industry to address the key issues the industry is facing to ensure the safety and integrity of the vital national and international steel pipeline infrastructure. The TDC provides the industry with an independent third-party site to thoroughly describe the capabilities of current pipeline inspection tools and to guide the development of new technologies needed to push toward the pipeline safety and integrity goal. The TDC enables efficient and timely access to industry samples in support of technology projects and programs. In 2021, The TDC was utilized by PRCI projects, for example NDE-4-18 Validate ILI Capabilities to Detect/ Characterize Mechanical Damage. .	
157	GO123	Tools and Methods to Assess Pipe Mat	20220811192355	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	7/28/2022	7/31/2023	$15,265	$59,000	$15,265	$0	_	Completed	$0	SCG $15,265.00 | PRCI Members $43,735.00	Reliability, Safety, Operational Efficiency, and Improved Affordability	Mid Stage (TRL 4-6)	Feasibility/Proof-Of-Concept; Deployment of Results; Share/Publish Results	The objective of this project is to perform a State-of-the-Art literature review of existing in-line inspection (ILI) and in-ditch tools to identify techniques with the potential to inspect the mechanical properties of steel pipe without the need for excavation. Technology companies have made a significant effort to develop in-ditch tools to measure mechanical properties. However, these technologies are used on the external surface of the pipeline and require exposure. An in-line tool option that characterizes mechanical properties, including fracture behavior and metallurgical properties, would be invaluable in confirming maximum allowable operating pressure (MAOP) and allow operators to approve these pipelines for hydrogen transport. This project will: 1) identify technologies that exist in the public domain from a variety of sources, including: ILI service providers, sensor, and surface hardness technology companies; 2) assess the status of each of the technologies from various sources and potential for application onto in-line tools; 3) evaluate and analyze the findings; 4) discuss technologies that exhibit potential; and 5) develop a comprehensive report summarizing the findings. SoCalGas could benefit from this project because obtaining precise information regarding pipe material properties is essential for MAOP verification and understanding the impacts of hydrogen blending on the transmission pipeline system. Additionally, this project could provide an option to gather information on pipeline materials at a lower cost due to excavation not being required, which will support SoCalGas in meeting pipeline regulations for integrity management.	_
158	GO124	UCLA Monitoring and Risk Assessment for Natural Force Damage to Pipelines (GFO-22-503)	2023090822018	Gas Operations	System Inspection & Monitoring	_	GeoHazard Threat Inspection and Monitoring	12/1/2023	10/31/2024	$15,000	$3,964,749	$0	$15,000	_	Active	$0	SCG $15,000 | CEC $2,992,909 | Others $956,840	Reliability, Safety, Operational Efficiency	Late Stage (TRL 7-9)	Further Technology Development/Prototype; Deployment of Results; Technology & Knowledge Transfer/Training	The objective of this project is to mature the seismic risk assessment software tools developed under the past CEC-funded project, "Seismic Risk Assessment and Management of Natural Gas Storage and Pipeline Infrastructure in CA (PIR-8-002),", by adding various data obtained from monitoring technology, including satellites, LiDAR, fiber optics, and pipeline sensors. The project will also use ground- motion measurements to predict pipe strain support, which can be used to expand and update the fragility database to combine direct and indirect measurements. The project will update the software platform created in project PIR-18-002 to work in near- real-time data and to provide training to California gas operators and industry partners on how to use the software. SoCalGas will use the results of this project to cover a wider range of ground motion scenarios and perform near real-time risk assessment based on reading field data which can reduce the risk of pipeline failure caused by natural hazards.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
159	GO125	Underground Natural Gas Storage and Risk of Corrosion/Souring (7.22.i)	20230711214133	Gas Operations	System Inspection & Monitoring	_	Corrosion Inspection and Monitoring	12/1/2023	7/31/2025	$31,724	$441,732	$0	$31,724	_	Active	$0	SCG $31724.00 | OTD Members $410,008.00	Safety, Operational Efficiency, and Improved Affordability	Early Stage (TRL 1-3)	Feasibility/Proof-Of-Concept; New Research Project to Advance TRL	The objective of this project is to better understand the risk and opportunities of microbial-hydrogen interactions in a storage reservoir. The project will focus on pure and natural-gas-blended hydrogen storage in the three commonly used storage types, aquifers, depleted hydrocarbon reservoirs, and salt caverns. The work will include 1) laboratory experiments simulating reservoir conditions using high-pressure bioreactor systems to collect data on changes in gas composition and microbial activities and 2) chemical and microbial analysis of the data. The deliverable will be a final report. In 2023, the project team held a kick-off meeting to identify field test sites and the associated reservoir parameters, temperature and pressure range. SoCalGas will provide field samples from at least two SoCalGas storge fields. The next step is to collect the field samples. The project team intends to use clean, renewable hydrogen for the laboratory tests. SoCalGas anticipates using the results of this research to identify solutions to manage integrity risks. SoCalGas will also use this research to gather information regarding the potential loss/conversion of hydrogen in a storage reservoir.	Hydrogen-Blending Project This project does not duplicate the hydrogen blending pilots (D.22-12-057) by: 1) The hydrogen blending pilot projects do not include underground storage. 2) The project will research the impact on pure and natural gas blended hydrogen on underground storage. SoCalGas has requested the use of clean renewable hydrogen to be included this projects scope.
160	GO126	Validate In-Line Inspection (ILI) Capabil	2020020622476	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	9/30/2019	12/31/2023	$25,722	$3,012,542	$25,722	$0	_	Completed	$0	SCG $25,722.00 | PRCI Members $2,986,820.00 | PHMSA $1,397,722.00	Reliability and Safety	Mid Stage (TRL 4-6)	Technology & Knowledge Transfer/Training	This project expands the current state of knowledge for In-Line Inspection (ILI) system performance to detect and characterize corrosion, welds, gouges, and crack features interacting with dents. The project will generate data to support the Pipeline Research Council International's (PRCI) research and development projects pursuing the development of revised dent response criteria. Additionally, it will address recommendations issued to Pipeline and Hazardous Materials Safety Administration (PHMSA) by the National Transportation Safety Board to promulgate new regulations that address dent acceptance criteria. In 2022, four vendors performed trial runs with their tools through mechanical damage test strings built at PRCI's Technology Development Center. The systems employed mechanical calipers and ultrasonic technologies for dent geometry. Ultrasonics were also used for metal loss and crack identification and sizing. The team used Magnetic flux leakage technology for metal loss. All vendors performed trials at multiple speeds, and they duplicated some of the speeds to collect various data sets, which they used to show repeatability and consistency, as well as provide backup data. The post-processing analysis is still pending, so PHMSA approved a project extension into mid-2023. The next steps are to finalize the data analysis and potentially perform more pull tests. SoCalGas can benefit from this research if the project results in revised dent response criteria based on engineering knowledge of the pipe conditions. It can then target excavation to pipe segments that meet the revised response criteria.	_
161	GO127	Validation of NDT Technology for PE Pipe (5.20.p)	20201023181952	Gas Operations	System Inspection & Monitoring	_	Pipeline Systems Inspection Technologies	10/1/2020	4/30/2024	$17,054	$200,000	$17,054	$0	_	Active	$0	SCG $17,054.00 | OTD Members $182,946.00	Reliability and Safety	Mid Stage (TRL 4-6)	Field Demonstration/Validation Testing	In this project, the team is evaluating the claims of commercially available nondestructive testing (NDT) technologies for polyethylene (PE) pipe and fitting joints. This evaluation includes heat fusion (e.g., butt and sidewall) and electrofusion (e.g., couplings, service tees, etc.) pipe joining methods. Industry stakeholders need to understand the capabilities and limitations of the various NDT technologies to determine whether the technologies are reliable for determining joint integrity. Previously, the team gathered information on sponsors' current use of NDT technologies on PE fusion joints with a survey. The project team held a workshop with stakeholders to review the capabilities of existing NDE technologies and to develop a roadmap for the next steps in evaluating them. Following the roadmap developed by stakeholders in the workshop, the types of test samples were chosen. Several NDT technology vendors have shown interest in participating in this study. Based on recent project team communications with vendors and the methods they use, however, it was determined that appropriate acceptance criteria for test samples should first be developed. In 2022, the project team worked on revising the project scope to include developing acceptance criteria, upgrading the control software on the butt-fusion machine that is used for the project, and preparing butt-fusion samples for testing. Once the project is completed, the team will deliver a final report detailing the NDT technologies identified, the validation test results, and supporting documentation for each pipe joining method, NDT technology, and NDT vendors. Additionally, the team will identify potential technology enhancements that would make the NDT technology for PE pipe more reliable.	_
162	~~GO126~~	~~Xray and Terahertz Development for NDE of PE Pipe by Iowa State University (M2019-007 Phase II)~~	~~2021012620269~~	~~Gas Operations~~	~~System Inspection & Monitoring~~	-	~~Pipeline Systems Inspection Technologies~~	~~1/20/2021~~	~~12/30/2022~~ 1/31/2023	~~$45,400~~	~~$407,019~~	~~$45,400~~	~~$0~~	-	~~Completed in 2022~~	$0	~~SCG $45,400 | NYSEARCH Members $361,619~~	~~Reliability, Safety, and Environmental: Reduced GHG Emissions~~	~~Mid Stage (TRL 4-6)~~	~~• New Research Project to Advance TRL Level • Further Technology Development/Prototype~~	~~The results of Phase I demonstrated the capability of X-ray radiography for polyethylene (PE) pipe inspection and paved the way to optimize a portable X-ray system in future phases of the project. X-ray radiography and computed tomography (CT) were shown to be complementary to terahertz (THz) methods in different aspects of PE pipe inspections. The objective of Phase II is to advance Iowa State University THz and X-ray NDE technologies with enhanced techniques that can interpret PE butt-fusion (BF) joint defects with 2D and 3D reconstruction imaging. THz and X-ray contour-following fixture construction will be performed, and defective BF samples will be developed and used for scanning, evaluating, and further developing the 2D and 3D scan data interpretation for each defect type. In 2021, the project team worked on redesigning the testing facilities to better handle the testing planned under the project. The project is awaiting The Welding Institute defected BF joint samples to begin testing.~~ -	-
163	48	~~GGZEM~~ ZEI Harbor Craft Demonstration	20201014173330	Clean Transportation	Off-Road		Off-Road	1/1/2021	12/31/2025	~~$200,000~~ $198,938	~~3401178~~ $3,400,116	~~$100,000~~ $148,938	~~$100,000~~ $50,000	$0	Retired	$25,000	CEC - $2,000,000 Ocean5 Naval Architects - $15,158 ZEI - $1,186,020	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	~~Mid Stage (TRL 4-6)~~ Late Stage (TRL 7-9)	Commercialization	In this California Energy Commission funded project, Golden Gate Zero Emission Marine (GGZEM) aims to develop and demonstrate a small, fast, hydrogen fuel cell powered, rigid inflatable boat for a variety of harbor craft use cases. GGZEM further proposes to develop and deploy supporting mobile and portable hydrogen fueling solutions. GGZM will demonstrate the vessel for six months in San Francisco Bay and Long Beach harbor. The project team will integrate a hydrogen fuel cell used by the automotive industry with a small, approximately 25-foot,commerically available rigid inflatable boat. Vessels under 40 feet in length have a wide variety of uses, including patrol, fire and rescue, fishing, pilot, excursion, ferry and taxi, and recreation. Developing a zero-emission hydrogen fuel cell vessel could help reduce emissions and improve air quality in and around harbors and ports. The vessel will be fueled through novel mobile, portable systems developed by GGZEM for marine vessel fueling and built through the project, using hydrogen sourced from California's retail hydrogen stations. GGZEM will apply their knowledge and experiences from the existing CARB funded 84-passenger hydrogen ferry project to this development. The project contracting was wrapped up in 2021, and work will commence in early 2022. .	
164	49	GTI Hydrogen Fuel Cell Switcher Locomotive Demonstration	20201014172728	Clean Transportation	Off-Road		Off-Road	1/1/2021	12/31/2025	$537,500	$5,964,876	~~$179,167~~ $358,333	~~$358,333~~ $179,167	$0	Retired	$150,000	CEC - $3,999,971 LCRI - $324,000 Sierra Northern Railway - $573,405 SMAQD - $500,000 Ballard - $30,000	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	GTI and Sierra Northern Railway will design, build, and demonstrate a hydrogen fuel cell, zero-emission, switcher locomotive in the seaport of West Sacramento. The project was awarded funding by the California Energy Commission's (CEC) Grant Funding Opportunity GFO-20-604: Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports (H2RAM), Group 1: Fuel Cell Demonstrations in Switcher Locomotives and Commercial Harbor Craft. Sierra Northern Railway will replace the diesel engine of a switcher locomotive with a hydrogen fuel cell, eliminating 10,000 gallons of diesel fuel use per year. This will improve local air quality and eliminate corresponding greenhouse gas (GHG) emissions. The locomotive will be demonstrated on Sierra Northern Railway's short-line operations which serve the railyard and seaport in West Sacramento.. It will remain in service after the demonstration period. The integration of advanced fuel cell and battery technologies represents a new platform that will enable commercialization within a few years. The project is in its earliest stages of activity, and ork is progressing to remove legacy diesel drivetrain, to design the fuel cell integration, and to acquire equipment for integration. .	
165	50	CTE Fuel Cell Electric Delivery Van Demonstration	2021100115636	Clean Transportation	On-Road		On-Road	11/1/2021	12/31/2024	$750,000	$15,229,320	~~$250,000~~ $500,000	~~$500,000~~ $250,000	$309,356	Retired	$75,000	CARB - $4,302,896 CEC - $744,755 DOE - $2,982,081 2,982,071 SCAQMD - $980,000 UPS - $5,469,588 5,378,490	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	~~Mid Stage (TRL 4-6)~~ Late Stage (TRL 7-9)	Commercialization	The Center for Transportation and the Environment (CTE) will develop and demonstrate 15 fuel cell electric delivery vans with UPS in Ontario, CA. Currently, there are no hydrogen fuel cell medium-duty vehicle for goods movement. UPS's existing battery electric fleet vehicles meet approximately 70% of UPS route range requirements. When configured with the fuel cell electric propulsion system being deployed by this project, the vehicle is expected to meet almost 95% of UPS service needs. The project will show that a van with UES's propulsion system can provide fleet operators with a zero-emission vehicle capable of meeting route range requirements while matching the performance characteristics of its existing fleet vehicles. According to Fleet DNA data compiled by the National Renewable Energy Laboratory (NREL), a vehicle with a 125-mile range will meet 97% of Class 3–6 daily delivery driving distances. Meeting CARB's desired 150-mile range threshold increases the attractiveness of zero-emission trucks to fleet operators and increases the commercial viability of fuel cell electric conversion kits. All fifteen fuel cell vans will be operated in routine UPS service for at least 5,000 hours of operation. During this period, maintenance and operational support will be provided by the Project Team. Throughout the period, all required operational data will be collected and reported. .	
166	51	Cummins Integrated Fuel Cell Electric Powertrain Demonstration	20201201205442	Clean Transportation	On-Road		On-Road	3/31/2020	12/31/2025	$240,000	~~$7,451,859~~ $3,764,624	~~$0~~ $24,000	~~$240,000~~ $216,000	$0	Retired	$80,000	Cummins - $1,484,390 DOE - $1,797,984 Navistar - $195,000 SCAQMD - $47,250	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	Cummins will develop and demonstrate a modular scalable fully integrated heavy duty fuel cell prototype design to be tested in a Class 8 Truck. Data will be collected and analyzed by CALSTART. The HD Class 8 truck demonstration will utilize a Cummins HD architecture with two fuel cell engines. Each of the engines consists of two stacks that together produce 90kW of power. The overall goal of the project is to demonstrate the feasibility of this modular scalable platform that utilizes a plug and play design for ease of installation as shown in the adjacent picture. The project seeks to demonstrate that the truck meet a 300+ mile range and exceed the current mileage limitations of pure battery electric HD vehicle solutions. The fully integrated powertrain that includes the fuel cell, battery, motor, inverter, and optimized controls will be installed as a vertically integrated solution to allow for overall cost reductions. The project team proposes to demonstrate the truck in Southern California.	
167	51-2	A1 Alt Fuels Fuel Cell Electric Paratransit Shuttle Demonstration	20210520161416	Clean Transportation	On-Road		On-Road	5/20/2021	4/30/2025	$531,166	$2,086,608	$516,166	$15,000	$0	Retired	$10,000	SCAQMD - $531,166 A1 - $132,668 US Hybrid - $508,000 Luxfer - $28,000 Sunline Transit - $160,608 Turtle Top - $85,000 Hometown - $110,000	Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	A1 Alternative Fuel Systems will develop and demonstrate two fuel-cell electric vehicles at Sunline Transit and Golden Empire Transit for 12 months. The vehicles include two class 4 medium paratransit shuttles, a low-floor (kneeling) Ford F-53, and a standard-floor Ford E-450s. The paratransit shuttles will be capable of a 175 – 250 mile range per fill. In addition to the demonstration, A1 Alternative Fuel Systems will test and certify the shuttles at the Altoona Test Center and for CARB on-road use. This project will help shuttle and transit fleets meet the California Zero Emission Bus Regulations and upcoming California Zero Emission Truck regulations within the required time frame. The team has developed the high-pressure fuel cell system used for the shuttle to easily integrate into other vehicle types that useintegrate into other vehicle types using the same Ford chassis. Ford's innovative design allows fleet operators to order a factory-built Ford cab and chassis, which they can configure as a wide variety ofvarious vehicle types, such as delivery trucks, work trucks, shuttles, and vans.	
168	51-3	CALSTART Hydrogen Zero Emission Tugboat Design	20201014173141	Clean Transportation	Off-Road		Off-Road	1/1/2021	2/29/2024	$100,000	$623,309	$100,000	$0	$0	Retired	$0	CEC - $498,309 CALSTART - $25,000	Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Early Stage (TRL 1-3)	Seek funding to build prototype	CALSTART has assembled a consortium of leading maritime stakeholders to design a hydrogen fuel-cell-powered zero-emission tugboat and support plans for refueling infrastructure. The consortium includes the following industry leaders: DNV-GL, ABB, Ballard, Chart, Crowley, Jensen, the Port of Los Angeles, and the South Coast Air Quality Management District. This project was awarded CEC grant funding through GFO-20-604: Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports (H2RAM) solicitation for Group 3: Design and Feasibility Study of Fuel Cell-Powered Commercial Harbor Craft. Tugboats are an essential component of port operations. Tugboats assist cargo vessels, tankers, and barges in and out of port complexes and play a role in other applications, such as firefighting. Tugboats have extreme power-tonnage ratios, typically two to four times that of normal cargo or passenger ships, and often feature two of each critical part for redundancy. They are highly maneuverable and currently use diesel engines that produce anywhere from 600 hp to over 20,000 hp and consume over 15,000 gallons of diesel fuel per month. A zero-emissions tugboat will advance state and national greenhouse gas emission reduction goals. To achieve the project objectives, the team will develop a design for a fuel cell-powered tugboat that they will use to inform future production and deployment. The team will also assess the economic feasibility, conduct a cost-benefit analysis, identify technology and regulatory barriers to using hydrogen in the maritime industry, and develop plans for the necessary refueling infrastructure – including hydrogen production and delivery pathways.	

	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
169	51-4	Frontier Energy MC Formula Protocol for H35HF Fueling Demonstration	20201109191041	Clean Transportation	Refueling Stations		Refueling Stations	1/1/2021	2/29/2024	$80,000	$705,000	$80,000	$0	$0	Retired	$0	DOE - $545,000 Shell - $20,000 SCAQMD - $25,000 Luxfer - $20,000 Sunline Transit - $10,000 Frontier Energy - $5,000	Reliability, Public and Employee Safety, Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Publish standard	This project will develop and test the MC Formula method for fueling heavy-duty-hydrogen-fuel-cell trucks at 5,000 psi using H35HF (high flow) dispensers. The MC Formula Method is a lumped heat capacitance model that calculates end-of-fill gas temp. Hydrogen refueling stations and protocols are responsible for safely fueling any hydrogen-fuel-cell vehicle. Commercial hydrogen refueling stations use the SAE J2601 Lookup Table (LT) method with limited temperature and pressure boundaries to safely refuel vehicles. The MC Formula method uses the actual pre-cooling temperatures of the dispenser as the control input. A key difference between the LT and MC methods for refueling is that the LT method uses feed-forward static controls while the MC method uses dynamic feedback controls. This method allows for high-flow scenarios and faster and more accurate filling of fuel cell vehicles.	
170	51-5	GTI CNG Plug-In Class 8 Hybrid Truck Development and Demonstration	20200117202314	Clean Transportation	On-Road		On-Road	11/1/2019	3/31/2024	$161,250	$1,765,438	$161,250	$0	$0	Retired	$0	CEC - $1,499,381 US Hybrid - $31,157 CWI - $53,650 SCAQMD - $20,000	Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	The goal of this project was to design, develop, and demonstrate a prototype control system integrated into a Natural Gas (NG) – Hybrid Electric Class 8 truck, optimized to achieve both near-zero oxides of nitrogen (NOx) emissions and significant greenhouse gas (GHG) savings. The vehicle used a 239kW 8.9-liter near-zero natural gas engine, a 222kW electric motor, a 31kWh lithium-ion battery pack, and electric accessories to provide equivalent performance to a larger 15-liter diesel engine while adding a 20-mile zero-emissions range. By comparing the emissions test results to engine emissions tests on similar platforms, the research team found that a hybridized near-zero powertrain can offer a 36% improvement in fuel economy and NOx emissions 22x lower than the current 0.02g/bhp-hr standard. Moreover, the team has found that 90% of NOx emissions are attributed to cold-start operations. Further research, optimization of the system, and support from the component manufacturers could yield additional improvements and offer NOx emissions rivaling well-to-wheel emissions of battery-electric vehicles. However, the NG HD-HEV technology would provide the range, reliability, and refueling convenience advantages over battery-electric alternatives. The team recommends further refinement and deployment of this technology, and they issued the final report to the CEC in Q4 2022.	
171	51-6	GTI CNG Smart Station Demonstration	2018102634	Clean Transportation	Refueling Stations		Refueling Stations	1/31/2019	3/31/2024	$268,754	$3,037,049	$255,316	$13,439	$0	Retired	$13,439	DOE - $2,040,384 CEC - $532,218 UT-CEM - $195,693	Reliability, Public and Employee Safety, Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Advance prototype	This project aims to address natural gas vehicle total cost-of-ownership by developing and demonstrating a smart fueling system that includes a full suite of necessary technologies that enable consistent full fills of natural gas vehicles. These technologies include a smart vehicle and dispenser, an advanced full-fill algorithm, and cost-effective gas pre-cooling using a near-isentropic-free piston expander and compressor. This combination of technologies solves the technical challenges of dispensing uncertainty and compression heat, resulting in underfilled natural gas vehicles. By eliminating under-filling, it may be possible to reduce the CNG fuel system's volume, weight, and cost by approximately 25% while increasing fuel economy, cargo capacity, safety, and driver experience. The GTI Energy and University of Texas Center for Electromechanics (UT-CEM) project team will perform system design, testing, and techno-economic analysis.	
172	51-7	GTI Energy Advanced On-board Hydrogen Storage Technology Assessment	20221106195154	Clean Transportation	Onboard Storage		Onboard Storage	11/28/2022	6/30/2024	$225,000	$225,000	$225,000	$0	$0	Retired	$0	N/A	Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Share information	This project aims to identify and test state-of-the-art onboard hydrogen storage technologies for transportation. Current vehicle hydrogen storage consists of high-pressure gaseous hydrogen, which requires a high volume to achieve the required runtimes. This project will be conducted in two phases. In Phase 1, GTI Energy will conduct a market assessment of advanced onboard storage technologies. This market assessment will identify the most promising state-of-the-art technologies to be evaluated in Phase 2. In Phase 2, following the market assessment, GTI Energy will evaluate, analyze, and support the technical development of three advanced onboard hydrogen storage technologies. These technologies are important for advancing fuel-cell electric vehicles because fuel storage systems are typically the largest individual cost component. Developing these technologies could yield the following benefits: increased volumetric energy density, reduced storage vessel costs, lower weight, resulting in increased payload and improved fueling efficiency.	
173	51-8	GTI Energy Cost-Effective Pre-Cooling for High-Flow Hydrogen Fueling Development	2021102715484	Clean Transportation	Refueling Stations		Refueling Stations	12/19/2022	12/31/2024	$268,750	$2,783,098	$150,000	$118,750	$0	Retired	$50,000	DOE - $2,197,984 UTD - $180,000 GTI Energy - $136,364	Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Advance prototype	This project aims to develop a high-flow pre-cooling system suitable for heavy-duty hydrogen fueling applications. The design will target the most cost-effective pre-cooling method possible by using commercially available components. The team will design the system to achieve the DOE target of 6 minutes, or 10 kg/min average fueling rate. Current chillers require more than 300kw of power. This project will target a peak power consumption of less than 200kW. The team will execute the project in three phases: 1) preliminary design, 2) sub-scale prototype development and economic analysis, and 3) performance testing of the sub-scale system, economic analysis updates, and commercialization plan. The team has identified and included performance and economic metrics in stage gates between phases. By the end of the project, the team targets having a performance-validated full-scale chiller design and commercialization plan in place with a manufacturing partner.	
174	51-9	GTI Energy H2 at Scale Hydrogen Refueling Demonstration	20200117201722	Clean Transportation	Refueling Stations		Refueling Stations	11/1/2019	12/31/2024	$483,750	$11,287,021	$483,750	$0	$0	Retired	$0	DOE - $5,400,000 Industry Partners - $5,403,271	Reliability, Public and Employee Safety, Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Share information	The H2@Scale project has two unique research, development, and demonstration tracks to understand better the potential of integrating hydrogen with multiple platforms throughout the economy. First, the project will include the demonstration of co-located multiple hydrogen generation and end-use applications at the University of Texas, Austin. Activities include 100% renewable hydrogen generation (steam methane reforming and electrolysis), a 100kW fuel cell powering a data center, and vehicle and drone refueling. In the second track, the project will leverage the experience from this demonstration and research and outreach to develop a framework for additional H2@Scale pilot opportunities.	
175	51-10	GTI Energy Symbio Class 8 Long-Haul Hydrogen Fuel Cell Truck Demonstration	20220111233238	Clean Transportation	On-Road		On-Road	11/1/2022	12/31/2024	$500,000	$5,148,158	$300,000	$200,000	$247,485	Retired	$35,000	CEC - $1,999,667 Symbio - $1,190,277 Michelin - $120,000 Faurecia - $820,214 TTSI - $318,000 UTD - $200,000	Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	The project aims to design, develop, and demonstrate an advanced hydrogen fuel-cell class-8 truck operating on a 400-mile route between Fontana and Lathrop, California, along the I-5 corridor in the San Joaquin Valley. The truck will match the performance of a 15-liter diesel vehicle utilizing proven pre-commercial core technologies, including a 400kW high power density Symbio fuel cell featuring stainless steel stacks, Faurecia's 60+ kg 700bar onboard hydrogen storage, and Michelin's advanced e-tires integrated into a widely adopted Freightliner Cascadia truck. The project intends to demonstrate the feasibility of fuel-cell vehicles on demanding regional haul routes where battery-electric trucks cannot meet the range or operational requirements. The vehicle will be fueled at public hydrogen fuel stations and from a mobile fueler deployed as required at one of the Michelin Commercial Service Networks along the route. The powertrain will handle challenging duty cycles such as the Tejon Pass ("the Grapevine") and extended freeway speeds in the San Joaquin Valley. Over the 12 months, the vehicle will travel over 60,000 zero-emission miles, most of them in disadvantaged communities across 7 California counties. Technical targets include a fuel cell system lifetime of 25,000 hours or 10 years/1,000,000 miles, at least 1.9x fuel economy improvement over equivalent internal combustion engine-powered vehicles, and total cost of ownership reduction of at least 30% compared to current fuel cell technology. The team will conduct a techno-economic analysis to compare the TCO of the next-generation fuel cell truck to existing technology.	
176	51-11	Immaterial Low-Cost Liquid Hydrogen Boil-Off Capture and Utilization Assessment	20220107195735	Clean Transportation	Refueling Stations		Refueling Stations	1/1/2022	12/31/2023	$245,572	$245,572	$245,572	$0	$118,263	Completed	$0	N/A	Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Early Stage (TRL 1-3)	Seek demonstration opportunities	Immaterial, a research, experimental development, and engineering firm built at the University of Cambridge (UK), has a unique technology, providing a step-change in the performance of Metal-Organic Framework (MOF) materials. This project aims to develop a computational fluid dynamics model of a cryo-adsorbed hydrogen boil-off management system and initial demonstration design. Simultaneously, Immaterial will develop second-generation optimized materials for boil-off conditions and a high-level techno-economic model. Immaterial will also identify target applications for their MOF technology. Boil-off – a phase change from liquid to gas – occurs when fluid, in this case, liquid hydrogen (LH2), is warmed by the energy transfer with the environment during vessel-to-vessel transfer. Boil-off is common along the LH2 supply chain, including vehicle refueling. Using MOFs to capture hydrogen boil-off can help reduce GHG emissions by capturing and using this otherwise wasted hydrogen. This approach can improve total costs by reducing hydrogen losses. First-generation Immaterial MOFs have demonstrated world-leading volumetric capacity, reaching storage capacities of 45g/L at 25 bar and 77 K as validated by the National Renewable Energy Laboratory. This strategy is already a 22% enhancement over the DOE record of 37 g/L at 100 bar and exceeds the current EU Horizon target of 40 g/L at 100 bar.	
177	51-12	Sandia National Labs Metal Hydride Composite Hydrogen Storage for Heavy Duty Vehicles	20200713155311	Clean Transportation	Onboard Storage		Onboard Storage	11/30/2020	2/29/2024	$575,000	$1,875,000	$575,000	$0	$0	Retired	$0	DOE - $1,300,000	Reliability, Public and Employee Safety, Operational Efficiency, Improved Affordability	Mid Stage (TRL 4-6)	Seek demonstration opportunities	This project aims to evaluate metal hydride composites as a materials-based storage medium to replace high-pressure hydrogen gas storage on Class 7 and 8 heavy-duty fuel cell electric trucks. The thermodynamic and kinetic properties of metal hydrides allow them to regenerate fully following hydrogen desorption at pressures much lower than 700 bar. For example, metal amides considered in this project can be revived at 100 bar, much lower than current onboard high-pressure hydrogen storage tanks (350 bar or 700 bar). Lower-pressure hydrogen could translate into more efficient storage tank designs that weigh and cost less than current high-pressure steel hydrogen storage tanks. Low-pressure hydrogen for vehicles can also increase reliability and reduce compression costs at refueling stations by utilizing lower-pressure compressors. An additional benefit is that knowledge generated by this project could assist in developing material-based storage for stationary applications such as microgrids and backup power for data centers. Sandia National Laboratory is still conducting its analysis. The team expanded the scope to include exploring material-based hydrogen storage for rail.	
178	51-13	SCAQMD and WVU Alternative Fuel Vehicle Maintenance Study	2020041519396	Clean Transportation	On-Road		On-Road	1/1/2020	3/31/2024	$150,000	$1,335,682	$150,000	$0	$0	Retired	$0	DOE - $1,085,682 SCAQMD - $100,000	Reliability, Improved Affordability	Foundational Research (Pre-TRL)	Share information	This project aims to study maintenance-related efforts and costs of medium- and heavy-duty vehicle engines powered by various alternative fuels across multiple vocations. The alternative fuels considered in this study are natural gas, propane, electric, and high biodiesel blends. This maintenance cost assessment incorporates the link between the operational characteristics of alternative fuel vehicles and how they affect maintenance and repair activity. The team will also perform a comparative evaluation of vehicle maintenance costs between natural gas and diesel-fueled vehicles. Vehicles included in the analysis are Class 6, 7, and 8, which the industry often uses in goods movement and delivery vocations. The project team will use vehicle maintenance costs of available fleet information, real-world vehicle activity, and in-use emissions data from another study upon which this project builds. The team will further leverage emissions and activity data previously collected and pre-established relationships from previous research.	
179	51-14	SCAQMD Ford 7.3L Near-Zero Emission Engine Development	2019092516423	Clean Transportation	On-Road		On-Road	11/30/2019	12/15/2023	$320,413	$3,021,247	$320,413	$0	$0	Completed	$0	SCAQMD - $619,588 Landi Renzo - $855,072 Agility Fuel Systems - $1,226,175	Reliability, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	This study aims to develop and commercialize the Ford 7.3L compressed natural gas (CNG) near-zero emission (NZE) Engine for medium-duty trucks. Widely untapped, the medium-duty truck market has not seen any near-zero-emission engines available other than the Cummins Westport, Inc. ISB 6.7 engine. The original plan was for three companies to develop and test engines. However, only one company, Agility Fuel Solutions, completed the project. Agility completed the development and certification process as of the summer of 2022. Agility developed all the hardware required to operate the Ford 7.3L engine on CNG and LPG fuel. After successfully demonstrating the ability to achieve a 0.02 g/bhp-hr NOx needed to meet the Low NOx standard requirements, Agility applied for certification with the US EPA and CARB. Additional testing showed the ability to meet 0.01 g/bhp-hr NOx using only engine calibration and OEM Ford exhaust systems. Durability testing was also performed, which demonstrated that Agility's modifications do not cause the Ford 7.3L engine to exceed any of Ford's established durability limits or not exceed thresholds. These are the first medium-duty class engines to reach near-zero emissions and will likely be widely adopted into Ford medium-duty truck platforms.	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
180	51-15	SCAQMD Hydrogen Blended Natural Gas in NZE Engine Emissions Study	20191014214310	Clean Transportation	On-Road		On-Road	11/21/2019	9/30/2024	$304,000	$534,000	$304,000	$0	$0	Retired	$0	SCAQMD - $232,000	Reliability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Seek demonstration opportunities	This research aims to provide data to justify the initiation of extensive validation work to increase the hydrogen limit for near-zero emission natural gas engines. This research project assesses the criteria pollutant and greenhouse gas impacts of hydrogen-natural gas fuel blends on near-zero NOx emission heavy-duty natural gas engines. Past studies have shown that adding hydrogen to natural gas may reduce engine emissions when combined with optimized engine calibration. The University of California Riverside's Center for Environmental Research and Technology will design and build a hydrogen-compressed natural gas (H-CNG) blending apparatus as part of the study and vary hydrogen content from zero to five percent by volume. The study's first phase focused on the emissions impacts of H-CNG blends compared to the baseline on regulated engine test duty cycles. CWI provided the test engine, after-treatment systems, engineering, data analysis support, and oil sample analysis. A 2005 comprehensive study by the National Renewable Energy Laboratory showed that an H-CNG-fueled engine reduced NOx emissions by 50 percent compared with a CNG-fueled engine in a transit bus application. Recent low-carbon and renewable fuel initiatives have renewed interest in further decarbonization of natural gas, providing a source of lower carbon content fuel for the transportation sector.	Yes
181	51-16	UC RIverside Hydrogen Blended Natural Gas Engine Durability Test	20200306212852	Clean Transportation	On-Road		On-Road	3/6/2020	9/30/2024	$364,977	$489,977	$364,977	$0	$0	Retired	$0	PG&E - $125,000	Reliability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Seek demonstration opportunities	This project aims to evaluate the impact of hydrogen content in natural gas on the performance and durability of one end-use technology, the Cummins L9N 8.9 liter near-zero natural gas engine. Cummins has a set limit for hydrogen content of 0.03% by volume, a long-standing limit probably based on typical natural gas composition. Since the limit is part of the Cummins specification, using natural gas with a hydrogen content greater than 0.03% could void the engine's warranty. The University of California, Riverside research team will operate the motor on hydrogen blended natural gas for 500 to 1,000 hours, simulating normal heavy-duty truck and transit duty cycles. After completing the 500 to 1,000 hours of testing, the research team will disassemble the engine to identify and analyze impacts on the components, fluids, and performance. The research will provide data to justify the initiation of extensive validation work to increase the hydrogen limit for near-zero-emission natural gas engines. Increasing the hydrogen limit in CNG engines will help reduce CO2 emissions.	Yes
182	51-17	US Hybrid CNG Plug-In Hybrid Electric Truck Demonstration	20200309182917	Clean Transportation	On-Road		On-Road	3/31/2020	3/31/2024	$250,000	$3,233,836	$250,000	$0	$0	Retired	$0	CEC - $1,135,000 SCAQMD - $500,000 DOE - $359,137 US Hybrid - $859,699 Clean Energy - $130,000	Reliability, Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Commercialization	The objective of this project is to develop and demonstrate an advanced Plug-In Hybrid Electric Truck (PHET) powertrain with an existing Cummins Westport Inc (CWI) L9N Near-Zero Emission (NZE) Compressed Natural Gas (CNG) engine on a Freightliner Cascadia sleeper-cab truck in a parallel hybrid configuration. The truck was optimized for over 1,000 miles of total range—including 35 miles of all-electric range—along with more than 600 horsepower to accommodate trucks that require more torque and power. The electric motor, coupled with the L9N CNG engine, will exceed the performance of existing 13-liter diesel engines while reducing carbon dioxide and NOx emissions and additional benefits if run on renewable natural gas. The team will use the truck as a demonstrator for fleets and events. The team will complete emissions and performance analysis through dynamometer and road-testing to assess the PHET design's overall advantage and emissions reduction. The truck is currently in operation with a host fleet.	
183	51-18	UTD CNG Dispenser Tank Communication (2.19.G)	2020040112010	Clean Transportation	Refueling Stations		Refueling Stations	9/1/2019	2/29/2024	$40,714	$250,000	$40,714	$0	$0	Retired	$0	UTD Members - $209,286	Reliability, Public and Employee Safety, Operational Efficiency	Mid Stage (TRL 4-6)	Advance prototype	The objective of this project is to design, build, and demonstrate a prototype smart compressed natural gas (CNG) station that includes a smart CNG dispenser and a smart natural gas vehicle (NGV). The team will develop pre-commercial prototype hardware and protocols that enable the vehicle and station to communicate information about the vehicle's fuel system, such as real-time pressure and temperature, tank volume, and age of the CNG fuel system. This approach will allow for safer, fuller fills of NGVs while enabling fleets to track a vehicle's fuel consumption more accurately. The project team has completed the design and bench scale development of a smart dispenser module that can communicate with the smart vehicle to improve full fills and completed lab testing of the smart dispenser components. The team also began the integration of the smart components with GTI Energy's CNG station to conduct testing with precooling to guarantee full fills of CNG vehicles. The team will share the results with UTD members after the project.	
184	51-19	UTD Next Generation NGV Driver Information System (2.20.F)	2021022523347	Clean Transportation	Onboard Storage		Onboard Storage	7/1/2020	2/29/2024	$15,400	$1,030,427	$15,400	$0	$0	Retired	$0	UTD Members - $242,300 Ozinga Bros Concrete - $772,727	Reliability, Operational Efficiency	Late Stage (TRL 7-9)	Pilot deployment	This project aims to develop and demonstrate a next-generation natural gas vehicle (NGV) driver information system that provides an accurate miles-to-empty estimate for the vehicle. This hurdle is particularly challenging in gaseous-fueled cars because the gas experiences a wide range of temperature fluctuations as the pressure changes during fueling and engine operation. UTD's co-funding will leverage the objectives of a separate prime contract award to GTI Energy by the U.S. Department of Energy (DOE) that provides $1,000,000 in federal funds plus $1,000,000 of in-kind partner support. GTI Energy will model the thermodynamics of the vehicle tank(s), the key technical hurdle for this project. Argonne National Lab will adapt a previously developed NGV fleet navigation application to utilize the miles-to-empty data to optimize fleet efficiency. After the DOE project, the team will engage potential commercial partners for licensing opportunities. In 2022, the project team successfully installed and demonstrated a truck's first Driver Information System. Once the display is validated, the team will install the system in 11 more vehicles. The team has also started discussing deployment in a commercial fleet.	
185	51-20	Yankee Scientific Strategies for CNG and Hydrogen Infrastructure Assessment	20210520161637	Clean Transportation	Refueling Stations		Refueling Stations	5/20/2021	3/31/2024	$148,100	$148,100	$100,000	$48,100	$0	Retired	$0	N/A	Operational Efficiency, Improved Affordability, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Foundational Research (Pre-TRL)	Share information	Yankee Scientific's goal for this project is to develop technical strategies to incorporate compressed hydrogen refueling capabilities at existing CNG refueling stations. The results of this project will allow for the accelerated deployment of hydrogen-fueled vehicles, thereby enhancing the use of renewable resources, reducing the generation of greenhouse gases, and improving air quality. In addition, this proposed program will support Transit Agencies as they develop strategies to meet the goals of the California Innovative Clean Transit (ICT) Regulations. Yankee Scientific will investigate methods to implement off-the-shelf components or to convert and share existing CNG station equipment for hydrogen refueling. This approach allows fleets to refuel CNG and hydrogen vehicles as they transition to zero emissions. The team will compare the economics of these technologies with tube-trailer transport of hydrogen from regional generation facilities or large industrial hydrogen suppliers. The team will identify strategies for adding equipment to the existing CNG refueling station. These studies will consider installing structures and equipment using standard site construction methods and prefabricated modular add-on systems when applicable. In addition, the team will evaluate each selected strategy's total station conversion and fuel delivery costs and complete a safety assessment. The team will develop recommendations for the best methods for incorporating hydrogen refueling.	
186	51-21	GTI Doosan Hydrogen Drone Demonstration	2020072715360	Clean Transportation	Off-Road		Off-Road	9/30/2020	1/31/2023	$257,062	$257,062	$257,062	$0	$7,734	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Share information	The project's goal was to advance hydrogen use in aviation by demonstrating Doosan Mobility Innovation's (DMI) hydrogen fuel cell drones for various applications. Hydrogen drones offer significant benefits compared to their battery-electric counterparts. DMI's hydrogen fuel cell drones have longer flight times (2 hours) and significantly shorter refueling times. GTI Energy worked with DMI throughout the project to showcase the technology at various conferences, including ACT Expo and CES. The drone was also demonstrated at two SoCalGas facilities and in Austin, Texas, as part of the H2@Scale project. These demonstrations highlighted the drone's extended flight time, efficient fuel tank swapping procedure, package delivery, and ability to conduct various infrastructure inspections. In addition to the demonstrations, GTI Energy also worked with DMI to assess the product design and operational procedures. This analysis included a review of pertinent codes and standards for the safe operation of the drone. GTI Energy presented this project at the Hydrogen and Fuel Cell Seminar in February 2023.	
187	51-22	GTI Energy Hydrogen Fuel Cell Yard Truck Port of Los Angeles Demonstration	20190422151928	Clean Transportation	Off-Road		Off-Road	1/1/2019	6/5/2023	$372,500	$12,017,657	$372,500	$0	$13,302	Completed	$0	CARB - $5,788,335 BAE - $3,005,971 Ballard - $1,000,000 Capacity - $212,043 Frontier - $20,000 HTEC - $50,000 TraPac - $1,568,808	Reliability, Public and Employee Safety, Operational Efficiency, Environmental Benefits: GHG Reductions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	Share information, Next-gen vehicle production/commercialization	The goal of this project was to validate the commercial viability readiness of zero-emissions hydrogen fuel cell electric yard trucks operating in a demanding, real-world cargo-handling application. Yard trucks are the largest source of emissions across all cargo handling equipment classifications. This project aimed to demonstrate to port terminal operators that fuel cell-powered, zero-emissions yard trucks are a safe, reliable, and operationally optimal solution to meet the port's clean air action plan. The project team, led by GTI Energy, accomplished these goals by successfully developing and deploying two fuel cell yard trucks at the Port of Los Angeles. This deployment and demonstration project was the first of its kind and has paved the way for similar future technologies in this space. A temporary refueling station was deployed on-site to ensure reliable refueling of the vehicles and to generate experience for proper evaluation of the impacts of the new technologies on port operations. The researchers credit future generations of hydrogen fuel cell-powered yard truck designs by Capacity largely to the information gathered and lessons learned by the technical project team. The team also gained eSimilarly, the experience with the hydrogen station permitting process and fueling operations provided with valuable insight into future technology deployments in off-highway, industrial, and cargo-handling applications. Extensive public outreach was conducted to share the results of this project, including a video, conference presentations, and webinars. The final report can be found here: https://www.gti.energy/demonstrating-safe-and-reliable-performance-of-hydrogen-powered-terminal-tractors-in-zero-emissions-for-california-ports-zecap-project/	
188	52	Bloom Energy Coupled Electrolyzer and Fuel Cell Demonstration	202102181213	Clean Generation	Distributed Generation		Distributed Generation	4/19/2021	~~6/30/2023~~ 12/31/2025	$500,000	$1,500,000	~~$300,000~~ $450,000	~~$200,000~~ $50,000	$0	Active	$0	Bloom Energy - $1,000,000	Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Next phase of future product development	The goal of this project is to demonstrate the coupling of Bloom Energy's new solid oxide electrolyzer cell (SOEC) at an existing Bloom solid oxide fuel cell (SOFC) installation. A 300kW SOEC will utilize grid electricity to generate hydrogen, which will then be blended with natural gas to fuel Bloom SOFCs. Hydrogen blending will take place downstream of the SoCalGas meter, at a manifold that will feed multiple existing SOFC units on the Caltech campus. The tentative blending percentage is 12% hydrogen (Bloom SOFC's can currently accept up to 50% hydrogen blends). The project will include SOEC product development, hydrogen blending design, permitting, and 15 months of operating costs. The demonstration will showcase the potential to decarbonize the natural gas grid and serve as a steppingstone to developing a reversible SOEC/SOFC fuel cell product. .	Yes
189	53	Noble Thermodynamic Systems Ultra-Efficient CHP Using a Novel Argon Power Cycle Development	2020031822540	Clean Generation	Distributed Generation		Distributed Generation	8/14/2020	~~10/31/2023~~ 12/31/2025	$500,000	~~$5,279,034~~ $5,115,494	~~$400,000~~ $475,000	~~$100,000~~ $25,000	$0	Active	$0	DOE - ~~$2,923,979~~ $3,900,306, Project Partners - ~~$736,868~~ $1,215,188	Reliability, Operational Efficiency, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to demonstrate the ability of the novel Argon Power Cycle (APC) to provide an 18% increase in efficiency, while eliminating emissions, in an internal combustion engine. The APC was developed by researchers at the University of California (UC), Berkeley. It utilizes a closed-loop internal combustion engine with argon as the working fluid (instead of air), in conjunction with a membrane gas separation unit. The closed-loop nature of the system completely eliminates air pollutants and GHG emissions. The project will take place at UC Berkeley, with work to be completed in two phases: 1) high-fidelity modeling and sub-component development; and 2) full system integration and operation. The team has progressed according to plan, with only a few minor delays due to supply chain issues. In the meantime, the team has completed the development of high-fidelity code simulating the entirety of the technology, integrating carbon capture technology, reciprocating engine power train, and heat transfer mode. Additionally, the team has completed the design of the overall plant and the design and manufacturing of the retrofit kit for the stock diesel engine. Engine performance estimates show engine efficiencies reaching as high as 62% on an engine scale normally delivering no more than 40%. The entirety of the system is under construction and expected to be ready for firing and integration by Q4 2022. The system will be operated for 18 months after commissioning. .	

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190	54	NREL GKN Metal Hydride Storage Integration with Renewable Energy and Fuel Cells Demonstration	20211206183920	Clean Generation	Integration & Controls		Integration & Controls	1/1/2022	6/30/2025	$400,000	~~$2,614,114~~ $2,983,229	~~$0~~ $250,000	~~$400,000~~ $150,000	$199,856	Active	$0	DOE - $1,722,089, GKN – ~~$492,025~~ $861,140	Reliability, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality, Safety	Late Stage (TRL 7-9)	Commercialization	This project will validate and demonstrate the dynamic operation of GKN's HY2MEGA metal hydride hydrogen storage system integrated with NREL's ARIES platform. The H2MEGA will be the largest metal hydride storage system ever built (520 kg H2 / 17.2 megawatt-hour). The project will be constructed at NREL's Flatirons Campus and will leverage the following ARIES resources: 1.25 MW PEM electrolyzer, 1.0 MW PEM fuel cell, 600 kg compressed H2, 6.3 MW controllable grid interface, battery, and renewable power assets. Renewable electricity will be used to produce green hydrogen via electrolysis, which will then be stored in the HY2MEGA system and a compressed storage system. That hydrogen will then be used to generate electricity via the fuel cell. Simulated energy production and consumption via the controllable grid interface will enable the team to validate the HY2MEGA performance in various real-world scenarios. These simulated use cases will include data centers and remote communities. The project will aim to achieve the following goals 1) Validate the storage and delivery performance of the HY2MEGA technology under a variety of charging and discharging conditions; 2) Demonstrate commercial use cases for a megawatt scale power system; 3) Determine the large-scale hydrogen storage efficiency for a materials-based technology; 4) Demonstrate a safe operating system. .	Yes
191	55	NREL Grid Forming Inverters for Fuel Cells Research	20211215171616	Clean Generation	Integration & Controls		Integration & Controls	1/1/2022	3/31/2025	$500,000	~~$1,689,000~~ $1,749,000	~~$150,000~~ $325,000	~~$350,000~~ $175,000	$233,166	Active	$0	DOE -$1,189,000, UCI - $60,000	Reliability, Operational Efficiency, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Early Stage (TRL 1-3)	Share/publish results	The purpose of project is to develop interconnection and interoperability standards for grid forming fuel cell inverters. Grid forming inverters are critical to maintain and regulate voltage and frequency for parts of the grid without traditional rotational assets (which typically perform this function). In the past few years, grid forming inverters have been successfully integrated with battery storage systems. Due to the operational differences between fuel cells and batteries, standards specific to fuel cell integration with grid forming inverters are needed. This project utilizes NREL's cutting edge ARIES research platform, which is capable of integrated systems modeling and testing at scales up to 20MW. The project will be performed in three phases: hardware-in-the-loop modeling, interconnection and interoperability requirement evaluation, and testing/validation of the developed standards in the ARIES platform. The project has three technical goals: demonstrating the ability of fuel cell inverters to transition between grid following and grid forming modes, interconnection standards (how fuel cells connect to the grid), and interoperability standards (how fuel cells communicate w/ other assets). .	Yes
192	56	UCI Fuel Cell Supported Nanogrid Controls Evaluation	2021082023224	Clean Generation	Integration & Controls		Integration & Controls	~~11/8/2021~~ 10/18/2021	~~4/30/2023~~ 9/30/2024	$436,653	$556,653	~~$275,000~~ $400,000	~~$161,653~~ $36,653	$0	Active	$0	Heila Technologies and Instant On -$120,000	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Late Stage (TRL 7-9)	TBD	The purpose of this project is to evaluate two microgrid control platforms in the context of a fuel-cell-supported residential microgrid ("nanogrid"). This project leverages the results of an ongoing project to develop and test a nanogrid control strategy designed to achieve zero net energy in a residential setting with a solid oxide fuel cell (SOFC), PV solar, and battery storage. The university of California, Irvine (UCI) will work with two microgrid controls vendors to evaluate and further develop the capabilities of its control platform(s). The microgrid controllers will be installed in UCI's laboratory nanogrid, which includes a 1.5kW SOFC, 5kW of rooftop solar, and a 9.8kWh battery. The control platforms will be tested for their ability to meet the dynamic operating requirements developed in the previously mentioned supporting project. In addition to the technical testing, UCI will evaluate the greenhouse gas and criteria pollutant emissions implications of the control strategies and determine the cost and equity implications of the test scenarios as applied to the residential demands of various California climate zones. .	
193	57	UCI Hydrogen Enabled Microgrids for Critical Infrastructure Research	20211027203855	Clean Generation	Integration & Controls		Integration & Controls	11/22/2021	~~12/31/2023~~ 12/31/2024	$362,442	$562,442	~~$225,000~~ $350,000	~~$137,442~~ $12,442	$0	Active	$0	Microsoft - $200,000	Reliability, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to demonstrate that hydrogen-based renewable fuels—in concert with a cheap and renewable power supply on the electric grid—provide the best techno-economic and long-term solution to meet both 100% renewable energy conversion goals and stringent reliability requirements for essential services like data centers and hospitals. This project leverages previous and ongoing Microsoft co-funded data center research. The University of California, Irvine will design and optimize a fully integrated energy system for a data center. System design will account for site loads, electrochemical energy conversion and storage devices (fuel cells, electrolyzers, batteries), renewable generation (on- and off-site), and dynamic integration with infrastructure grids (electric, gas, water). Optimizations and comparisons will be based on technical capabilities, achieved reliability, and cost. .	
194	58	UTD High-Efficiency Combi System Integrating PV and Self-Power - Phase 2 (1.20.G.2)	20210820181519	Clean Generation	Integration & Controls		Integration & Controls	7/1/2021	7/31/2023	$95,769	$450,000	~~$48,000~~ $95,769	~~$47,769~~ $0	$0	Active	$0	UTD Members -$354,231	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions	Mid Stage (TRL 4-6)	TBD	The goal of this project is to develop and demonstrate a hybrid residential combined HVAC and water heating (combi) system in the laboratory that uses off-the-shelf appliances and novel controls to integrate gas-electric systems with micro combined heat and power (mCHP), energy storage, and renewable energy in order to improve efficiencies, reduce greenhouse gas emissions, reduce operating costs, and increase resilience. GTI has successfully operated the nanogrid to achieve self-powered hybrid residential HVAC and water heating using the mCHP system and thermal/electric energy storage to power the combi system and air source heat pump (ASHP). The nanogrid controller manages the various power sources including mCHP, grid power, and solar PV. By using thermal heat recovery from the micro-CHP system together with the ASHP and supplemented with the tankless heater as necessary, GTI is targeting annual coefficients of performance greater than 1.0 serving heating loads down to 5,000 BTUs per hour. GTI is now implementing a test plan to determine the performance of various system configurations: grid parallel, islanded, and integrated with simulated solar PV generation. .	
195	59	UTD Integrated mCHP System for Multi-family Building - Phase 2 (1.20.J.2)	202102250221	Clean Generation	Integration & Controls		Integration & Controls	7/1/2021	7/31/2023	$139,249	$480,000	~~$70,000~~ $139,248	~~$69,249~~ $0	$0	Active	$0	UTD Members -$340,751	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	TBD	The goal of this project is to leverage the results of Phase 1, which integrated a Lochinvar CHP, distributed air source heat pumps, and thermal storage in an integrated energy system (IES). This project will expand the capabilities of the system to further test and demonstrate the capabilities of the IES in a multifamily setting. The project team will integrate electric vehicle charging, PV integration, and hydrogen blending in a microgrid configuration to demonstrate resiliency and efficiency benefits. The system will be designed and evaluated in both grid-connected and islanded configurations. .	
196	59-2	EPRI ORC Waste Heat Recovery Demonstration	SCG15100138	Clean Generation	Distributed Generation		Distributed Generation	12/1/2015	3/31/2024	$121,593	$1,118,332	$121,593	$0	$0	Active	$0	CEC - $996,739	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Potential field demonstration	The goal of this project is to demonstrate the technical and economic feasibility of a cost-effective organic rankine cycle (ORC) package to recover very low-grade waste heat from natural gas industrial processes. The project team will install a commercially available ORC system at a SoCalGas customer site for monitoring and verification. This will represent the state's first application of ORC technology in an industrial setting. When complete, the project will identify key factors dictating project economics, lifecycle costs, and opportunities for improvement and optimization that could lead to further market adoption and better economics.	
197	59-3	GTI Aisin Residential Fuel Cell Laboratory Testing	2020120201322	Clean Generation	Distributed Generation		Distributed Generation	12/14/2020	3/30/2024	$343,702	$343,702	$343,702	$0	$0	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency, Reliability, Affordability	Late Stage (TRL 7-9)	Potential field demonstration	This project aims to evaluate a residential solid oxide fuel cell (SOFC) for commercialization and widespread deployment in California. SoCalGas acquired two 700W SOFC units from Aisin to be assessed by GTI Energy. The units were modified versions of the commercially available systems in Japan. Modifications include tuning for U.S. gas composition and adding an external transformer for electrical connectivity in the lab.	
198	59-4	GTI Energy Kyocera Residential Fuel Cell Laboratory Testing	20220701231627	Clean Generation	Distributed Generation		Distributed Generation	12/19/2022	3/31/2025	$300,000	$330,000	$250,000	$50,000	$66,619	Active	$0	Kyocera - $30,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Late Stage (TRL 7-9)	Potential field demonstration	The ultimate goal of this project is to develop a residential fuel cell for commercialization and widespread deployment in California. To help achieve this, SoCalGas will acquire two 400W SOFC units from Kyocera to be evaluated by GTI Energy. The units will be modified versions of the commercially available systems in Japan. Modifications will include tuning for US gas composition. The team will operate the systems with an external transformer for lab testing. GTI Energy will work with SoCalGas and Kyocera to develop a test plan, which will, at a minimum, assess the following items: power characteristics (I-V data), power capacities and efficiencies of the system at various loads, system endurance, and stack degradation, load following capabilities, system cycling, start-up and shut-down times, emission rates, heat recovery potential, and stand-alone operation.	
199	59-5	GTI Energy Marathon/EC Power mCHP Testing and Demonstration	2018060164	Clean Generation	Distributed Generation		Distributed Generation	7/1/2018	12/31/2024	$100,000	$1,657,006	$100,000	$0	$0	Active	$0	CEC/ MES,/AO Smith - $1,499,406, ECPower - $47,600, Axiom - $10,000	Environmental: Improved Air Quality, Operational Efficiency, Reliability	Late Stage (TRL 7-9)	Commercialization	The objective of this project is to test and demonstrate two micro-combined heat and power (mCHP) systems—a 4.5 kW Marathon and a 25 kW Lochinvar—to certify both systems under the CARB Distributed Generation Certification Program (CARB-DG).	
200	59-6	GTI Energy Mobile Hydrogen Fuel Cell Generation System Demonstration (CEC MORBUGS)	20220404224915	Clean Generation	Distributed Generation		Distributed Generation	12/21/2022	12/31/2024	$300,000	$2,632,074	$300,000	$0	$0	Active	$0	CEC - $1,99,953, EPRI- $332,121	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Late Stage (TRL 7-9)	Commercialization	This project aims to design and build four easily transportable, integrated hydrogen fuel cell backup generators. Each system will consist of a hydrogen fuel cell, hydrogen storage, battery energy storage, power conversion system, customer and grid interconnection resources, energy management, safety, and monitoring systems. The system, built by Renewable Innovations, will self-sufficiently support a minimum of 10 kW, with 35 kW of continuous load for more than 24 hours, with a peak load capacity of 180 kW. The system will be fueled by hydrogen, providing an opportunity to replace high-emitting diesel backup generators with fuel cell systems that have virtually no emissions and little noise.	Yes
201	59-7	GTI Energy Upstart Residential SOFC Lab Evaluation	20200709164722	Clean Generation	Distributed Generation		Distributed Generation	8/17/2020	8/31/2023	$206,481	$206,481	$206,481	$0	$29,785	Completed	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Late Stage (TRL 7-9)	Evaluate Nex Gen Product	This project aimed to evaluate the performance of the Upstart Upgen 10 residential solid oxide fuel cell (SOFC) system at GTI Energy's lab. The technology was originally designed to operate on propane, but modified for testing with natural gas. Unlike other SOFC systems, Upstart claims they created the system to achieve fast start and stop times while maintaining cyclic durability. SOFCs can improve customer energy reliability while reducing GHG and pollutant emissions.	
202	59-8	Mainspring Energy Ultra-Low NOx Linear Power Generator Demonstration	2018091843	Clean Generation	Distributed Generation		Distributed Generation	1/1/2021	3/29/2024	$100,000	$3,767,940	$100,149	$0	$0	Active	$0	CEC - $995,659, Mainspring - $2,672,132	Environmental: Improved Air Quality, Operational Efficiency, Reliability, Affordability	Late Stage (TRL 7-9)	Commercialization	The goal of this project is for Mainspring Energy to demonstrate their linear generator in a real-world setting. The demonstration took place at a Kroger grocery store in Colton, CA, a disadvantaged community. Mainspring's linear generator uses a low-temperature reaction of air and fuel to drive magnets through copper coils to efficiently produce electricity with near-zero NOx emissions.	
203	59-9	QSI Nano-Power Generation System Proof-of-Concept	20190826205436	Clean Generation	Distributed Generation		Distributed Generation	9/9/2019	11/14/2023	$50,000	$50,000	$25,000	$0	$0	Cancelled	$0	N/A	Operational Efficiency,	Early Stage (TRL 1-3)	Product Development	This project aimed to conduct a proof-of-concept test of the QuSwami, Inc (QSI) patented Nano-Power Generation System, running on natural gas. QSI's system utilizes Electricity Emitting Diodes (EEDs), which directly and efficiently generate power from an energy source via gas-phase catalytic reactions. The reactions occur on an EED's nano-surface, where hot electrons are generated. QSI's foundational research shows that direct conversion of chemical energy from gas-phase catalytic reactions can achieve higher fuel efficiency than most existing electricity generation technologies	
204	59-10	UCI Capstone H2 Blending Research	2022113023433	Clean Generation	Distributed Generation		Distributed Generation	12/1/2022	1/31/2024	$100,393	$100,393	$100,393	$0	$0	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability	Foundational Research (Pre-TRL)	Share/publish results	This project aims to build upon past research to understand better and address the emissions impact of blending H2 into Capstone microturbines. Prior research indicated that 20% blend levels could be achieved in the C-65 and C-200 models without any observed flashback. However, NOx increases were observed, and controllable via system settings up to a limit. Beyond 20% blending has demonstrated the need for additional system modifications to control emissions.	Yes
205	59-11	UCI Effect of Hydrogen Addition into Natural Gas on SCR of NOx Lab Testing	20200915234440	Clean Generation	Distributed Generation		Distributed Generation	10/5/2020	3/31/2024	$300,000	$300,000	$285,000	$15,000	$99,928	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Early Stage (TRL 1-3)	Share/publish results	This project aimed to investigate the impact of hydrogen-blended natural gas on the performance of selective catalytic reduction (SCR) units for removing nitrogen oxides (NOx) from flue gas. SCR of NOx is used in several applications, such as gas-fired utility boilers, process heaters, gas turbines, and stationary engines. Flue gas composition is known to affect catalyst performance. Since hydrogen is a carbon-free fuel, the combustion products differ from those that contain carbon. Introducing a flue gas with a different composition into the SCR unit affects the chemistry occurring on the catalyst and, hence, its performance. The team thought that this might cause a change in the resulting NOx emissions downstream of the SCR unit, which would be released from the stack.	

	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
206	59-12	UTD Capstone C200S Microturbine Laboratory Evaluation (2.18.E)	20200410225957	Clean Generation	Distributed Generation		Distributed Generation	7/1/2018	6/29/2023	$19,800	$185,000	$19,800	$0	$0	Completed	$0	UTD Members -$165,200	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Share/publish results	This project aimed to evaluate and characterize the performance of the newly launched 200 kW Capstone C200S Signature Series microturbine as a pathway for GTI to scale up its FlexCHP technology. GTI's microturbine FlexCHP technology is an industrial steam/hot water solution that has the potential to enable grid-independent operation with high energy efficiency , without the need for costly post-combustion treatment.	
207	59-13	UTD Emerging Rescom Fuel Cells - Laboratory Evaluations (1.20.F)	20210224162442	Clean Generation	Distributed Generation		Distributed Generation	7/1/2020	6/29/2023	$27,789	$190,000	$27,789	$0	$0	Completed	$0	UTD Members -$162,211	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Mid Stage (TRL 4-6)	Share/publish results	This project aimed to evaluate the merits of residential and small-commercial scale fuel cell systems (<50kW), prioritize them based on fitness for the North American market, and conduct lab testing of select designs. GTI Energy assessed sixteen fuel cell configurations, including alkaline, solid oxide, and polymer electrolyte technologies, all identified for residential or commercial combined heat and power applications. The project team evaluated the merits of the systems based on electrical efficiencies, manufacturer reputation, successful field demonstrations, and North American market fit.	
208	59-14	UTD EnviroPower 6kW SmartWatt and BRASH 3kW STRAUM mCHP Boilers - Lab Test (2.19.E)	20200410224621	Clean Generation	Distributed Generation		Distributed Generation	7/1/2019	6/30/2024	$22,588	$190,000	$22,588	$0	$0	Active	$0	UTD Members -$167,412	Operational Efficiency, Reliability,	Mid Stage (TRL 4-6)	Share/publish results	The objective of this project is to evaluate the 6kW EnviroPower and 3kW BRASH STRAUM Micro-CHP (mCHP) self-powered hydronic HVAC boiler systems in the laboratory, and support their development by validating performance and other competitive analysis benchmarking. Evaluation metrics will include power, thermal production, efficiencies, and emissions.	
209	59-15	Blue Frontier Fuel Cell Integrated Air Conditioning System Dynamic Lab Testing	20210930231913	Clean Generation	Integration & Controls		Integration & Controls	10/18/2021	2/29/2024	$250,000	$493,635	$250,000	$0	$0	Active	$0	CEC - $243,635	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to expand the development and testing of the Blue Frontier AC (BF AC) system, which is a liquid desiccant air conditioner that can be paired with a fuel cell CHP to utilize and store "waste" heat to provide space cooling. Phase 1 involved prototype development, static testing, and conducting an extensive analysis of the benefits of the BF AC, which showed significant energy, cost, and emissions savings when paired with a fuel cell CHP system. This phase of the project will expand the scope to include dynamic testing at UC Davis Western Cooling Efficiency Center (WCEC), who has expertise in this type of testing. Testing will evaluate the performance of the BF AC when subjected to dynamic inside and outside conditions (informed by the building types and climate zones modeled in Phase 1) in psychrometric chambers (rooms where environmental conditions can be controlled and simulated)	
210	59-16	Blue Frontier Fuel Cell Powered HVAC Development	20191010175342	Clean Generation	Integration & Controls		Integration & Controls	11/1/2019	2/29/2024	$540,527	$540,527	$540,527	$0	$0	Active	$0	N/A	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Potential field demonstration	The goal of this project is to further the development of the Blue Frontier Air Conditioning (BFAC) system and investigate its integration with a fuel cell CHP system. By using an Enhanced Liquid Desiccant Energy Storage technology originally developed by NREL, the BFAC recovers and stores the waste heat from the fuel cell in order to provide on demand cooling.	
211	59-17	UCI Fuel Cells in Data Centers Research	201906241897	Clean Generation	Integration & Controls		Integration & Controls	10/1/2019	12/31/2023	$190,000	$540,000	$190,000	$0	$0	Completed	$0	Microsoft - $350,000	Reliability, Operational Efficiency, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Next phase of future product development	The objective of this project is to explore the real-world feasibility of using Solid Oxide Fuel Cells (SOFCs) integrated with an absorption chiller to provide power and cooling to a data center. The waste heat from the SOFCs is being used to drive the absorption chilling process. The project is being conducted in UCI's laboratory. For the purposes of testing, a standard 42 slot server rack was provided by Microsoft. In order to meet the 12kW power requirements of the server rack, the project team is using eight 1.5kW Solid Power BlueGEN fuel cells. A 5-ton Lithium Bromide (LiBr) absorption chiller from Yazaki was selected for cooling	
212	59-18	UCI Integrated SOFC, Solar, and Storage System in ZNE Residential Nanogrid Design	20190624172734	Clean Generation	Integration & Controls		Integration & Controls	10/1/2019	1/31/2024	$325,000	$325,000	$325,000	$0	$0	Completed	$0	N/A	Reliability, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Share/publish results	The goal of this project was to design and analyze a residential "nanogrid" that integrates a solid oxide fuel cell CHP system, PV solar, and battery storage to achieve Zero Net Energy (ZNE). The project team has evaluated sixteen climate zones for component sizing and considered system configurations for four scenarios: 1) All Electric: PV + Battery; 2) All Electric: PV + SOFC + Battery; 3) Mixed Fuel: PV + Battery; 4) Mixed Fuel: PV + SOFC + Battery.	
213	59-19	UTD Integrated CHP System for Multi-Family Buildings (1.20.J)	20210224162728	Clean Generation	Integration & Controls		Integration & Controls	6/1/2020	8/30/2023	$30,000	$250,000	$30,000	$0	$0	Completed	$0	UTD Members -$220,000	Reliability, Operational Efficiency, Improved Affordability, Environmental Benefits: Reduced GHG Emissions, Environmental Benefits: Improved Air Quality	Mid Stage (TRL 4-6)	Share/publish results	This project aimed to evaluate a laboratory microgrid design featuring an EC Power/Lochinvar XGRi25micro combined-heat and power (mCHP) unit within a multi-family context,coupled with best-in-class electric heat pumps (EHPs) responding to heating and cooling demand.	
214	60	GTI Model-Based Control Hospital Dec	2020101532851	Customer End-Use Applications	Commercial Applications		Commercial Applications	12/1/2020	3/31/2024	$161,250	~~$1,585,954~~ $6,768,954	~~$80,000~~ $147,000	~~$81,250~~ $14,250	$0	Active	$0	CEC - $1,424,704	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report, Technology & Knowledge Transfer Activities	This project will demonstrate an integrated model-based control solution for reducing space heating and hot water loads in order to decarbonize large commercial buildings. The proposed technology will significantly reduce energy use and GHG emissions. GTI will monitor and report real energy savings and GHG reductions from the installation of advanced technologies at the Baldwin Park Medical Center. The goals of the project are to demonstrate an overall 30% reduction in natural gas usage and a simple payback of less than 3 years, advance the technologies integrated with model-based optimal control from TRL7 to TRL9, and showcase the retrofit measures and energy savings through outreach to encourage similar implementation of energy saving measures throughout the state. In 2021, the project team held their first technical advisory committee meeting on 7/2021 to share their project progress. During their meeting, they shared their analysis on the site characterization including technical information on the boiler and chiller systems used by the medical center. They also discussed their baseline monitoring plan which was submitted on 3/2021 and next steps in the project which include addressing outstanding metering issues, fine tuning energy models, and drafting the final hospital baseline energy usage and modeling report.	
215	61	UTD CleanO2 CARBiNX Carbon Capture (1.21.C)	20210822222945	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2021	~~1/31/2023~~ 5/31/2024	$30,000	$150,000	$30,000	$0	$0	Active	$0	UTD - $120,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will evaluate the performance of a CleanO2 CARBiN-X v 4.0 carbon capture device in a laboratory setting in order to validate claims of a carbon dioxide capture rate of 4 metric tons per year and cost savings of at least 30% for hot water heating. It will furtherand identify areas for continued technical improvement. Besides the CARBiN-X v 4.0, CleanO2 is working on more advanced prototypes that look to further disrupt the distributed carbon capture market. Depending on the progress in the development of these prototypes, GTI may perform preliminary regulatory and technical analyses to support advancement of this technology. Implementing distributed carbon capture technology such as the CARBiN-X will help reduce greenhouse gas emissions in the residential and light commercial and industrial spaces while retaining natural gas in Zero Net Energy Buildings.	
216	62	UTD Commercial Heat Pump Water Heater Field Performance Comparison (1.21.F)	20210822223940	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2021	~~1/31/2024~~ 6/30/2025	$4,707	$916,000	$4,707	$0	$0	Active	$0	UTD Members - $161,293 PERC - $30,000 DOE - $720,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	In this project, a comparison between commercial gas and electric heat pump water heater technology will be conducted in one or two field locations as well as in GTI's laboratory using ASHRAE standards to establish the cost and energy saving capability of each technology. The goals are to assess the performance of of these technologies under various conditions, , and to provide equitable comparative information between commercial heat pump technologies. The project agreements were finalized in 2021, and work is expected to begin in early 2022.	
217	63	UTD Gas Engine Heat Pump Modeling, Testing, and Implementation (1.21.E)	2021082222354	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2021	~~1/31/2024~~ 1/31/2025	$7,631	$320,000	$7,631	$0	$0	Active	$0	UTD Members - $312,369	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will validate natural gas engine-driven heat pump (GEHP) performance for variable refrigerant flow (VRF) systems across a range of conditions. It will expand the market through enhanced energy models using measured performance data, validation of a new method of testing (ANSI/CGA) for new GEHP performance metrics, a technoeconomic assessment to determine the best use of three new GEHP equipment options. These options includeAHU integration kits, Yanmar Hydrobox, and Aisin Hi-Power. The project agreements were finalized in 2021, and work is expected to begin in early 2022.	
218	64	UTD Gas-Fired Binary Fluid Ejector Heat Pump Water Heater (1.20.E)	2021022503444	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2020	~~7/31/2023~~ 5/31/2024	$19,125	$2,080,000	$19,125	$0	$0	Active	$0	UTD Members - $160,875 DOE - $1,900,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project models, designs, and builds prototypes of a gas-fired ejector heat pump water heater (GFEHP). This first-of-a-kind heat pump uses a novel cycle that combines a binary-fluid ejector and sorption subsystem into one high efficiency cycle. The technology integrates several components that are thermally and hydraulically coupled. The overall objective is to develop and demonstrate GFEHP technology at 12,000 Btu/hr (3.5 kW) capacity in the laboratory and to achieve a COP of 2.0. This will make it twice as efficient as the current state-of-the-art technology on a primary energy basis. This will help retain a high-efficiency role for natural gas for more than 80 million residential users of gas fired water heaters in the U.S. alone. The research team is finalizing the burner design and will begin designing and developing the heat-exchanger system between the flue gas and the working fluid.	
219	65	UTD Hydrogen-Blended Gas in ResCom Combustion Equipment - Phase 2 (1.20.H.2)	20210822222121	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2021	~~7/31/2023~~ 3/29/2024	$4,350	$150,000	$4,350	$0	$0	Active	$0	UTD Members - $145,650	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will support the potential deployment of up to 30% hydrogen blended gas in North America in commercial and residential buildings, by assessing operational performance, emissions, and safety impacts on at least five standard appliances in a laboratory setting. Specific goals of Phase 2 are to determine the impact of hydrogen blends on efficiency rating and seasonal performance on appliances, to project greenhouse gas (GHG) reduction potential of hydrogen blending at various levels for U.S and Canadian blocking stocks, and to identify safety, emissions, and efficiency benefits or concerns.	
220	66	UTD Ionic Liquid Absorption Heat Pump for Commercial Water Heating (1.21.I)	2021091522323	Customer End-Use Applications	Commercial Applications		Commercial Applications	12/31/2021	~~12/31/2023~~ 6/30/2024	$2,400	$225,000	$2,400	$0	$0	Active	$0	UTD Members - $222,600	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	The objective of this project is to design and demonstrate in a lab environment an "alpha" working prototype of a low-cost, ultra-high efficiency gas-fired commercial heat pump water heater with a novel semi-open absorption cycle (SOA-GHPWH) that uses a benign ionic liquid, and which provides integrated latent cooling to further maximize efficiency. The target efficiency is COPgas,HW ≥1.60 if only providing hot water, or COPtotal ≥1.80 if also providing indoor cooling and dehumidification. The prototype will be performance-tested at loads (steady and dynamic) typical of commercial buildings with 100 gallons storage and nominal heating output of 145 kBtu/hr. The system uses a simple plastic pump, and most materials of construction are polymers.	
221	68	UTD Sequestering Non-Condensable Gases for Enhanced GHP Reliability - Phase 2 (1.19.E.2)	20210822221232	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2021	~~7/31/2023~~ 6/30/2024	$2,364	$240,000	$2,364	$0	$0	Active	$0	UTD Members - $197,636 SMTI, Robur - $40,000	Operational Efficiency, Safety, Reliability, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	To successfully advance the use of high-efficiency gas absorption heat pumps (GAHP), it is important to minimize the impact of non-condensable gases on long-duration performance and reliability. The goal of this project is to design and develop non-condensable gas isolation (NCGI) modules and provide research and development support to employ novel, low-cost aluminum heat exchangers to increase long-term system efficiency and reliability and safe operation and reduce the cost of any absorption-type heat pump. The project team plans on demonstrating the performance of the technology in a prototype GAHP. In 2020 through 2021, the project team initiated and completed rounds of corrosion testing with the alloy samples. In parallel, university researchers are initiating atmospheric pressure testing.	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
222	69	UTD Thermoelectric Generator for Self-Powered Water Heater - Phase 4 (1.17.B.4)	20210822215444	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2021	~~7/31/2023~~ 6/28/2024	$6,000	$1,280,000	$6,000	$0	$0	Active	$0	UTD Members - $234,000 DOE - $1,000,000 AO Smith, Sheetak, Marlow - $40,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	The objective of this project is to develop a self-powered, gas-fired tankless water heater to save rate-payers money and energy while enhancing resiliency. In Phase 4, the team will design, build, and test a working alpha prototype. Phase 4 will build upon the hardware testing performed in prior phases to develop the critical components and integrate the design to power a condensing tankless water heater. GTI plans to utilize UTD's Phase 4 funding as cost share to leverage a next round of funding from DOE towards implementing this technology. Phase 4 will also leverage GTI's efforts and relationship with DOE BTO on a related current DOE BTO project, as well as past UTD projects. .	
223	70	UCI Hydrogen Blend Commercial Stove	20210820204140	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	11/1/2021	~~11/1/2023~~ 1/31/2024	$305,000	$305,000	~~$100,000~~ $200,000	~~$205,000~~ $105,000	$0	Active	$0	N/A	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability	Mid Stage (TRL 4-6)	Final Report, PowerPoint, Peer-Reviewed Article, Press Release, Webinar	Currently, NOx emissions from cookstoves are not subject to regulation, but they are a strategic end-use device to be considered for future building emissions reduction. While studies suggest a modest decrease in NOx when low amount of hydrogen is added to natural gas in typical stove burners, the levels still approach 80-90 ppm. Reduction in NOx emissions can be achieved by i) reducing the combustion temperature, ii) decreasing the flue gas residence time in the high temperature zone and iii) reducing the excess O2 in the fuel/oxidizer mixture. Catalytic combustion provides the advantage of lowering the temperature of the oxidation reaction, thus resulting in significantly lower NOx emissions. Catalytic combustion of hydrogen and natural gas has been studied in literature separately for various applications. However, there is no study on the evaluation of fuel blends, resulting NOx emissions, and application for commercial cooking. Therefore, in the proposed work, an ultra-low NOx catalytic burner will be designed and built to burn natural gas/hydrogen blends (up to 50%) for commercial cooking applications. This work will be the phase I of a two-phase study. After burner development, phase II will include development of a commercial prototype and involve a commercialization partner to help with the commercialization process. Since the research agreement was executed in late Q4 of 2021, there are no project updates to report. .	
224	71	UTD Gas Fired Warewasher Door Mach	20210822224724	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2021	~~7/31/2023~~ 7/31/2024	$19,938	$145,000	$8,938	$0	$0	Active	$0	UTD Members - $125,062	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	UTD Final Report	The objective of this project was to develop gas-fired prototypes of two types of warewashers (dishwashers): the doortype (low-volume) and the conveyor-type (high-volume). These represent a combined 43% segment of the warewasher market. Presently, most commercial warewashers are electric driven, and many electric warewashers use chemicals rather than high temperatures to disinfect, which further increases their environmental impact. Initial estimates indicate a site will only use one-third of the source energy with a gas warewasher compared to alternative technologies. Even a low-usage restaurant, with onl 1,100 therms of annual usage, would reduce the carbon footprint of the restaurant from 49,610 pounds of CO2 per year with electric units to 16,088 pounds of CO2 per year with gas-fired units. In this project, researchers and a manufacturing partner modified current electric-driven warewashers. Different heat exchanger designs were modeled to determine the best-performing designs that fit into the needed footprint of an existing electric warewasher. Prototype heat exchanger(s) were fabricated and put into a prototype along with a burner and blower. A functional prototype was tested for combustion efficiency, safety, and emission standards. Researchers modeled 13 variations of different heat-exchanger designs and tested the combustion system in the laboratory with the prototype tank and heat exchanger. Custom controls were used to tune everything, and excellent results (under 10ppm NOx) were achieved. Technicians assembled the burner, blower, and gas valve assembly, along with a new control for the combustion system. Initial testing of the combustion system in the prototype heat exchanger was completed. .	
225	72	UTD High Efficiency Smart Convection Oven - Phase 2 (1.19.A.2)	2021082222442	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2021	~~7/31/2023~~ 6/30/2024	$49,111	$215,000	$49,111	$0	$0	Active	$0	UTD Members - $120,889 Blodgett - $45,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	In this project, researchers are incorporating a heat exchanger to recover heat from the flue and feed it back into the combustion air. The objective is to develop a prototype high efficiency smart convection oven that increases efficiency by at least 5%, and also integrates superior smart operating controls to maximize food preparation quality and consistency. Earlier, researchers investigated a high-efficiency oven design, showing that this design in bench-scale tests was able to achieve a 3% improvement to cooking efficiency and a 10% improvement to preheat energy use despite not being fully optimized. Based on these results and areas for improvement that were found in that initial design, the project team anticipates that a 5%-10% cooking efficiency should be achievable once the design has been optimized. In addition, a targeted 10%-20% reduction in NOx and CO emissions are expected. In 2021, the project team completed basic testing on the modified heat exchanger. Pre-mix testing will follow. The proposed design is targeted to be 10% more efficient than current ENERGY STAR designs. When compared to installed ovens, it could save more than 50% of the energy use (i.e., over 400 therms per year). A 50% savings translates to $300 in savings annually for the customer (assuming $0.75 per therm) compared to baseline existing ovens. It would be expected to pay back in one to two years, since the cost premium may only be around $300-$400. Discussions with a leading manufacturer continue regarding commercialization opportunities and other next steps to make this more efficient oven available to end users. .	
226	73	GTI Booster Ejector Enhancement of Co	2020101525135	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	12/1/2020	~~12/31/2023~~ 3/31/2024	$110,000	$1,731,556	$45,000	$65,000	$0	Active	$0	CEC - $1,621,556	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	GTI Final Report, CEC Final Report, Press Release, Webinars, Journal Publication (ASHRAE, ASME, and food processing journals)	In this CEC funded project (EPC-19-023), the project team is developing a Booster Ejector Enhancement of Compressor Refrigeration (BEECR) for field demonstration. The proposed solution recovers steam from a gas-fired cooker, extracts the waste heat and water, and sends the waste steam through the ejector which then drives the chiller displacing the consumption of electricity from the refrigeration cycle. Natural gas and water will be saved through utilization of the waste steam for facility needs and providing pre-heating/boiler infeed water heating. The project seeks to achieve at least a 20% reduction in energy consumption in addition to water savings and significant reductions in nitrogen oxides, particulate matter, and greenhouse gas emissions through energy savings. In October 2021, the project team submitted a draft report to the California Energy Commission pertaining to system design, baseline testing, and a field test plan. By the end of 2021, the project team had made progress towards completion of system installation and package monitoring. The project team of GTI, Wilson Engineering Technologies (WET), and Tetra Tech is currently finalizing the measurement and verification plan and the piping and instrumentation diagrams. GTI and WET are coordinating with the chiller and compressor manufacturers—Multistack and Danfoss—to finalize overall system design, including the booster ejector system and heat recovery unit to be installed on the boiler exhaust. Tetra Tech is planning to install a fuel flow meter on the boiler to measure the boiler load profile, which will inform the design of the heat recovery unit, and a buffer tank for thermal energy storage. .	
227	74	GTI Waste Heat Effective Transfer in Br	2020101535820	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	12/1/2020	3/29/2024	$177,821	$1,948,387	~~$47,664.5~~ $136,214	~~$130156.5~~ $41,607	$53,205	Active	$0	CEC - $1,410,566 Tower and Campus Brewing - $100,000 UTD Members - $270,000	Environmental Benefits: GHG Reduction, Environmental Benefits: Air Quality Improvement, Operational Efficiencies, Improved Affordability	Late Stage (TRL 7-9)	CEC Final Report, Technology & Knowledge Transfer Activities, Commercialization Plan	In this CEC sponsored field demonstration (PIR-19-004), a Waste Heat Effective Transfer (WHET) technology will be installed in the flue of two micro-distilleries. The WHET recovers waste heat from the brew kettle to provide preheated plant water in the facility hot water tank which will result in significant reduction in natural gas consumption and emission. The WHET is unique because it utilizes a low-cost heat exchange module made of modified tubing that provides excellent heat transfer in minimum space and minimum pressure drop. The tubing surface features disrupt boundary layers which increases gas mixing, resulting in increased average gas temperature, and higher overall heat transfer rates as compared to its competitors. The objectives of this project are demonstrate a cost-effective, modular, and unintrusive waste heat recovery solution that can be installed in a variety of industrial applications and achieve a 15 to 25% recovery of heat from the brew kettle which would result in natural gas savings and the lowering of emissions (carbon dioxide and NOX).	
228	75	UCI Solid Oxide Electrolysis Cells for Gr	202012142447	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	3/1/2021	3/1/2024	$550,000	$5,699,861	~~$275,000~~ $550,000	~~$275,000~~ $0	$183,418	Active	$0	DOE - $4,043,993 UCI, Politecnico di Milano, FuelCell Energy, Inc., LEAP - $1,105,868	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Mid Stage (TRL 4-6)	DOE Final Report, Technoloy Transfer Plan, Production Readiness Plan, Journal Publications, Conference Presentation, DOE Webinar/Press Release	The objective of this project is to study, demonstrate, and optimize an integrated, zero-emission prototype for the direct reduction of iron with H2 produced from a SOEC system. The project is a close collaboration of academia (University of California, Irvine and Politecnico di Milano), industry (FuelCell Energy, Inc.) and a technology transfer company (LEAP). In 2021, the team determined the specific primary energy consumption < 8 GJ/ton DRI for the best performing Hydrogen Direct Reduction configuration at nominal load. Three system configurations have been proposed representing incrementally integrated layouts between the SOEC unit and the shaft furnace. Additionally, the team completed a SOEC model validation on voltage-current curves with an average prediction error <5% on the steam electrolysis experimental measurements. The model predicted electric-to-hydrogen production efficiency of < 35 kWh/kg (or >95% with 120 MJ/kg of H2 Lower Heating Value) at nominal design steady-state conditions. The project team plans to complete validation of SOEC co-electrolysis model for Hybrid HDR scenario with literature data, begin pressurized stack testing at FCE's manufacturing site, optimize system layouts for steam electrolysis scenarios, and initialize system configurations for co-electrolysis (hybrid HDR) in 2022. .	
229	77	UTD High Hydrogen Burner for Commercial and Industrial Applications (2.21.A)	2021082223515	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	7/1/2021	~~7/31/2023~~ 1/31/2024	$84,000	$340,000	$84,000	$0	$0	Active	$0	UTD Members - $216,000 ORNL, CalSteel, Gopher Resources, ANL - $40,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will design, fabricate, and test an advanced fuel-flexible hydrogen/renewable natural gas (H2/RNG) 0.5 to 1 MMBH burner in a commercial scale furnace at GTI's laboratory. The team will partner with two leading large industrial end-users and two national laboratories to ensure that the final prototype burner meets the requirements of the representative end users. GTI has successfully developed and bench-scale tested a 3D-printed burner design at 0.05 MMBH scale capable of operating efficiently and robustly with hydrogen up to 40% H2. The funding will demonstrate a scaled-up burner with higher hydrogen (up to 60%) to evaluate and commercialize the technology with California Steel, Inc. (CSI), Gopher Resources, Inc., Oak Ridge National Laboratory (ORNL) and Argonne National Laboratory (ANL). Actual field testing of the prototype will be separately funded/authorized. The project agreements were finalized in 2021, and work is expected to begin in early 2022. .	
230	79	Lantec Development of Ultra Low NOx	2019041616262	Customer End-Use Applications	Residential Appliances		Residential Appliances	5/1/2019	12/31/2023	$92,500	$432,500	~~$37,530.5~~ $70,383	~~$54,969.5~~ $22,117	$26,855	Retired	$0	SCAQMD - $340,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Mid Stage (TRL 4-6)	SCAQMD Final Report, Certified Low NOX Furnace	The goal of this project is to achieve the design, development, performance and operational testing, certification, and commercialization of residential condensing and non-condensing forced air furnaces utilizing MicroNOx ultra-low NOx combustion technology emitting no more than 7 ng/J NOx. This project will take a novel burner technology "MicroNOxTM", developed by Lantec Products from its current early product development stage along the product readiness levels to a point where the manufacturing partner has a viable product to begin introduction into a commercialized product line. The project team will test the prototype units in accordance with the certification test procedure contained in AQMD Rule 1111 including AQMD Method 100.1. The prototype furnaces will also be tested against ANSI Z21.47 including 10,000 combustion cycles as prescribed within the standard. In 2021, the project schedule was delayed by COVID-19. Despite this, Lantec focused on finalizing the condensing and non-condensing prototype design and completion of non-condensing retrofit furnace. The project team anticipates delivery of the furnaces to GTI for operational testing based on ANSI Z21.47 standards by March 2022. .	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
231	80	ORNL Residential Hydrogen Blended Sp	20210831175330	Customer End-Use Applications	Residential Appliances		Residential Appliances	11/1/2021	~~11/1/2023~~ 9/30/2024	$600,000	$600,000	~~$50,000~~ $225,000	~~$550,000~~ $375,000	$0	Retired	$207,750	N/A	Safety, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Improved Affordability	Mid Stage (TRL 4-6)	Final Report, Journal Article, Press Release, Webinar, Techno-Economic-Environmental report, Commercialization Plan, IP/Patent	In this project, a residential space heater will be retrofitted with a flameless heterogeneous burner technology to develop a clean and safe space heating appliance capable of operating on hydrogen and natural gas fuels; emissions, safety, turn-down, reliability, and efficiency will be addressed in designing the space heater. When hydrogen is introduced to the fuel mixture, special attention to flame velocity and temperature must be considered. Conventional burners lead to high NOx emissions due to the extreme flame temperature and high flame velocity makes it susceptible to flashback, thus creating safety hazards. Both factors can inhibit usage of hydrogen blended fuel in building heating equipment. Therefore, a low temperature, flameless, heterogeneous catalytic oxidation burner is ideal for safely converting the fuel energy into the desired heat quality. The primary focus of the proposed effort is to enable higher hydrogen blended fuels in a 40k Btu/h space heating system which would accommodate the typical 2000 sq ft home. The objectives of the project are to design, fabricate, evaluate, and optimize a burner capable of operating on natural gas containing up to 40% hydrogen, conduct a techno-economic-environmental analysis to support the business case, study the compatibility of the developed burner with different commercial systems with regards to form and fit with the goal of designing a universal retrofit kit, and identify and engage with an OEM towards a commercialization pathway. .	
232	82	UTD Mitigating Methane Emissions from ResCom End Use Equipment - Phase 3 (1.18.F.3)	2021082222623	Customer End-Use Applications	~~Residential Appliances~~ Commercial Applications		~~Residential Appliances~~ Commercial Applications	8/1/2021	~~8/31/2023~~ 12/31/2024	$19,000	$150,000	$19,000	$0	$0	Active	$0	UTD Members - $131,000	Safety, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	Final Report, Journal Article, Technoeconomic Analysis, UTD Webinar	This project will quantify methane emissions from at least six key residential appliances that have not been quantified in past phases of the project, in order to develop and publish representative methane emission factors and to determine the conditions under which these appliances release unburned methane and identify potential mitigation options. At least six residential appliances, including cooking ranges and tank water heaters, will be tested under specific operating conditions and representative use patterns, including both steady-state, standby, and cyclic operation. .	
233	82-2	METRON Energy Virtual Assistant (EVA	20200805223421	Customer End-Use Applications	Advanced Innovation		Advanced Innovation	8/31/2020	~~12/31/2023~~ 12/31/2024	$601,069	$601,069	$334,860	$266,209	$67,031	Active	$0	$0	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	Final Report	This project will demonstrate METRON's "Energy Virtual Assistant (EVA) Factory Solution", which optimizes industrial processes utilizing machine learning. All types of data from industrial equipment (boilers, chillers, compressed air, dryers, etc.) are captured and processed by the METRON-EVA platform. The platform allows for "non-intuitive optimization," real-time access to data, and easy reporting. METRON hopes to achieve a payback period of fewer than 12 months, and up to 15% total energy savings (electric and gas combined). The goal is to test and demonstrate the technology at up to three (3) locations. Depending on the site, commissioning can be achieved with minimal hardware installation or remotely (if the customer already has monitoring equipment). Frontier Energy will provide independent, third party measurement & verification of the savings. In 2021, the project team interviewed several potential host sites and selected a manufacturer of high-performance composite materials and products for the aerospace and transportation industry. The team decided to focus on one pilot site to guarantee a successful demonstration rather than three. During the site analysis, the project team identified several pathways for significant energy savings including modifications to parameters that affected the electricity, steam generation, vacuum pump, compressed air, expansion, and incinerator processes. In 2022 the team worked on the instrumentation and connectivity of the steam generation and incinerator processes. The energy optimization software has been installed at the host site. The plant managers are familiarizing themselves with the energy dashboard which has high-level control over the plant's operation. The team is working to bring online more variables in the system.	
234	82-3	UTD Gas Fired High Efficiency Liquid De	20190204235233	Customer End-Use Applications	Advanced Innovation		Advanced Innovation	6/1/2018	3/31/2024	$4,000	$415,000	$4,000	$0	$0	Active	$0	UTD Members, NYSERDA - $411,000	Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The goal of this project is to develop a gas-fired liquid desiccant dedicated outdoor air system (LDDOAS) that addresses many of the critical issues facing the HVAC industry. During this project, a research team is collaborating with a manufacturer to compare the current state-of-the-art LDDOAS technology with other advanced systems. The team designed and experimentally evaluated a breadboard LDDOAS test rig rated at approximately 100 CFM using a novel, non-corrosive, non-toxic desiccant. In Phase 1, the project team constructed an experimental gas-fired liquid-desiccant air-conditioning system. In Phase 2, the team upgraded a one-tower test rig and completed liquid desiccant distribution tests. Progress was made on continuous regeneration tests, demonstrating efficiency as high as 70% while sufficiently regenerating the desiccant. In 2021, the project team conducted rigorous testing of dew point sensors and determined that an energy imbalance detected in earlier testing was not due to instrument accuracy. The project team discovered that insufficient mixing of water vapor in the air at the exit of the tower was causing the imbalance. To make certain proper mixing of the air as it exits the tower, the project team constructed a reducer for the top of the tower to increase the flow velocity and turbulence. In 2022, the team completed plans for building a second packed bed column tower to allow for simultaneous regeneration and conditioning. Construction of the second tower is currently underway. The group purchased a new digital refractometer to measure the desiccant solution's refractive index. The project team plans to begin benchtop tests of the desiccant on different material surfaces in the next reporting period.	
235	82-4	CSU Hydrogen Blend on a Caterpillar N	2021060920511	Customer End-Use Applications	Commercial Applications		Commercial Applications	9/1/2021	1/31/2024	$173,066	$203,066	$173,066	$0	$23,085	Active	$0	In-Kind - Caterpillar (engine equipment) - $30,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability	Mid Stage (TRL 4-6)	Final Report	This engine testing research aims to assess the impact of hydrogen blends on the emissions and performance of a rich-burn engine with a non-selective catalytic reduction catalyst (NSCR). The goal is to test how various fuel-to-air ratio control processes can mitigate impacts. Researchers hypothesize that more advanced systems and controls are needed to accommodate blends with hydrogen content to remain in compliance with air quality requirements. Approximately 1,000 - 2,000 engines are in operation in the SoCalGas service territory, used for water pumping, distributed power generation, and pipeline gas compression. This research could help develop a statewide hydrogen injection standard and a better understanding of hydrogen blending in commercial and industrial (C&I) equipment. The study will also benefit disadvantaged communities because most engines are in municipalities, water companies, and farming areas. Successful project completion will allow the C&I team to work with customers to retrofit their engines before they receive hydrogen blends. In 2022, the research team completed the hydrogen blending system setup, and shortly after, they completed the engine testing. The team is now reviewing the data on hydrogen fuel blending and developing appropriate air-fuel-ratio (AFR) control strategies. The team intends to submit a research paper to the Society of Automotive Engineering's 2023 conference, covering emissions, sustainability, and thermal management topics.	
236	82-5	GTI Gas Heat Pump Water Heating and	179214311	Customer End-Use Applications	Commercial Applications		Commercial Applications	4/17/2017	12/31/2024	$226,000	$1,090,294	$226,000	$0	$0	Active	$0	CEC - $864,294	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report	The goal of this project is to pilot a low-cost gas-fired heat pump (GHP) for integrated commercial water heating and air-conditioning (A/C). The project team deployed the technology at two restaurant sites in the Los Angeles basin. The GHP is a direct-fired, single-effect absorption heat pump using an ammonia/water working pair with an operating heating Coefficient of Performance of 1.40-1.90 (fuel HHV basis). In prior laboratory testing and field applications for space heating, it has an estimated Annual Fuel Utilization Efficiency of >140%. The team anticipates having an equipment cost of approximately half that of comparable GHP equipment. To offset A/C energy consumption, the project team modified this GHP to deliver hot water and supplemental A/C, sized to provide 80 kBtu/h of hot water and 2.5 tons of cooling simultaneously, with 4:1 modulation. Stone Mountain Technologies, Inc. (SMTI) designed this GHP, a startup company specializing in gas-fired heat pumps, with technical support from GTI ENERGY and A.O. Smith. After the project, the research team found that energy savings at both sites were 16%-26% for the Integrated GHP System and 52%-53% for the heat pump. The daily net electricity increase for both sites was 7-8 kWh. The energy savings translate to $970- $2,780/year, or $620-$2,530 when including electricity and using mature quantity production estimates of GHP and other standard equipment costs. The simple payback for the Integrated GHP System ranges from 1.1 to 6.4 years (fuel savings basis). Lastly, the climate impact of the technology yielded a net greenhouse gas reduction of about 46-48% using 2018 CA-statewide emission factors. The project is pending a CEC final publication.	
237	82-6	Momentum Gas Heat Pump Demonstr	2020062416115	Customer End-Use Applications	Commercial Applications		Commercial Applications	6/30/2020	12/31/2024	$55,000	$1,201,850	$55,000	$0	$0	Active	$0	SoCalGas Customer Programs, CEC - $1,146,850	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report	The project's goal is to optimally deploy a state-of-the-art natural gas heat pump technology into a hotel. This technology holds the potential to reduce greenhouse gas emissions greatly and air quality impacts to local communities and populations collocated with this facility while demonstrating energy savings of at least 35% in the form of natural gas consumption (target 50%). In this project, SoCalGas is leading an effort to deploy and demonstrate the technical and economic viability of high-efficiency natural gas heat pumps. The pilot is located at the Westin Bonaventure, a 1.5 million square foot hotel in a low-income and disadvantaged community. In 2021, the host site decided they could no longer support the technology demonstration. As a result, the project team spent most of the year developing a turnaround strategy, including identifying alternative sites. With the assistance of the CEC, several meetings were held with the project team to narrow down candidates, including a large university and a major television production facility. In 2022, the project team finalized contracting for an alternative site, and the group expects procurement of the GHP components in 2023.	
238	82-7	UTD High Hydrogen-Content Fuel in Re	2021022503743	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2020	3/31/2024	$18,900	$179,900	$18,900	$0	$0	Active	$0	UTD Members - $161,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability	Mid Stage (TRL 4-6)	N/A	The objective of this project is to adapt and demonstrate solutions to use high-hydrogen blends (>50% hydrogen by volume) and 100% hydrogen in residential and commercial combustion equipment. The aim is to show multiple solutions in a controlled laboratory environment and leverage international developments and technology transfer. The project goals are 1) to build a hydrogen-blend and experimental test station. Then use the test apparatus to evaluate the performance of hydrogen-compatible prototypes, products, and components from an emerging network of global developers; 2) develop a research and development roadmap to identify and address gaps and opportunities with high-hydrogen-compatible stationary combustion equipment; and 3) use the new hydrogen-blend experimental test station to disseminate and demonstrate the technology, including hosting outreach events with a wide range of stakeholders. In 2021, the project team developed a comprehensive review of hydrogen demonstrations in Europe and Asia that included end-users. In 2022, test stands were built and modified for standardized testing of furnaces and water heaters. The project team completed a preliminary literature review on relevant test and certification methods. The research team developed a comprehensive test plan, with testing expected to occur in the first quarter of 2023. As part of the R&D road mapping and outreach efforts under this project, the team prepared a summary paper for the World Gas Conference held in May 2022. Researchers demonstrated that methane emissions decrease with added hydrogen. There are several emerging options for distributed gas quality and hydrogen sensors. The project team is meeting with representatives from several sensor manufacturers.	
239	82-8	UTD Next Generation Infrared Burner -	2021022504326	Customer End-Use Applications	Commercial Applications		Commercial Applications	6/1/2020	2/29/2024	$9,200	$300,000	$9,200	$0	$0	Active	$0	UTD Members, Solaronics, Alantum Corp - $290,800	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The objectives of this project are to design, build, and test prototype high-efficiency, high-performance, low-emission gas-fired infrared burners that use advanced metal foam material to offer end users new high-efficiency products. The project team collaborated with material and burner manufacturers. Using gas-fired infrared (IR) heaters instead of electric-driven IR heaters can significantly reduce both source energy emissions and end users' operating costs. This project aimed to build on earlier developments to advance a gas-fired IR burner for commercial and industrial use. In this project, researchers investigated advanced metal foam IR burners with better material properties. In 2022, the project team performed heat-flux measurements for the different conditions and compared them with the performance of traditional IR burners. Researchers reviewed the data from the host site, which looked promising. The team expects more discussions with the manufacturing partner and the host site and more data gathering.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
240	82-9	GTI SCAQMD HE/Low-NOx EcoZone Bu	20191029201215	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	11/1/2019	3/31/2025	$350,000	$2,202,000	$150,000	$200,000	$0	Active	$0	SCAQMD, Kroger, SoCalGas Energy Efficiency - $1,852,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Late Stage (TRL 7-9)	CEC Final Report	The project objective is to demonstrate at least 25% NOx emission reduction by optimizing the combustion process in a multi-zoned commercial baking oven within a South Coast Air Quality Management District environmental justice area. The team estimates a 10% reduction in carbon dioxide emissions through combustion system optimization. The goal is to install the major components of the demonstration system (such as the innovative high-efficiency low-NOx ribbon burners and flame analyzers along with advanced combustion and flow controls) on a multi-zone baking oven at a major commercial bakery located in La Habra, California. The project team will follow this step by testing and performing data collection over a wide range of operating conditions to illustrate the anticipated energy savings and environmental benefits. The proposed approach provides the means to minimize carbon monoxide, carbon dioxide, and NOx emissions while operating the burners at the most efficient firing rate possible at every moment of the baking process. Due to limitations caused by COVID-19, the team was delayed in completing field engineering and demonstration system installations until mid-2021. Fortunately, the team turned the project around in August of 2021 when they installed the demonstration system (i.e., the modified combo-burners and oven control system). In 2022, the team was able to successfully startup and shakedown the demonstration system. They are now actively collecting data and monitoring the performance of the EcoZone burner.	
241	82-10	UTD CFS Burner Technology Carbon Re	2022062222313	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	8/31/2022	8/31/2024	$10,000	$160,000	$10,000	$0	$0	Active	$0	UTD Members - $150,000	Reliability, Safety, Operational Efficiency, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The objective of this project is to determine the decarbonization potential of typical commercial food service (CFS) appliances when utilities blend up to 30% hydrogen with natural gas. Phase 2 will focus on full appliance testing and cooking performance impacts and build on the testing of standalone burners and controls in Phase 1. GTI, through its contacts at the North American Foodservice Equipment Manufacturers, will work with CFS manufacturers to identify and supply appliances for testing. Some key performance indicators include the production of efficiency and emissions data for various stock CFS appliances. The team will observe hydrogen blends operating between 0-30%. The team will also create initial recommendations for relevant limits on hydrogen for a spectrum of stock CFS appliances. Finally, the project group will assess possible near-term modifications (e.g., controls or burner designs) to increase allowable hydrogen content. In 2021, a laboratory setup was designed and assembled to test CFS burners. The project team tested a fryer pilot burner as part of the shakedown of the test stand and data-acquisition system. During the shakedown, the team identified a need for a different capture hood and a more accurate gas flow meter. The project team addressed both issues, and testing resumed. In 2022, the team completed testing with the fryer pilot burner. The project team is currently testing a tube burner.	
242	82-11	UTD Commercial Foodservice Equipme	202102250176	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2020	7/31/2024	$9,000	$90,000	$9,000	$0	$0	Active	$0	UTD Members - $81,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	N/A	This project aims to provide end users, utilities, and researchers with the ability to quickly evaluate appliances, whether gas-fired or electric, and understand their performance. Researchers gathered valuable data from a restaurant and commercial cooking field demonstrations to quantify the operating and efficiency benefits of gas-fired commercial food service equipment in real-world situations. The team tested some of the industry's most recent market introductions, including a steam kettle, range, wok, conveyor oven, convection oven, boiler-less steamer, low-oil-volume fryer, and grill. The team-focused activities were in two areas. The first area focused on single-day demonstrations at test kitchens and trade shows, illustrating how well specific equipment performs. The second area focused on long-term demonstrations in restaurants.	
243	82-12	UTD Gas Fired Warewasher - Phase 2 (	2021022502521	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2020	7/31/2024	$8,529	$175,000	$8,529	$0	$0	Active	$0	UTD Members, Hobart - $166,471	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The project objective was to develop a gas-fired prototype of a conveyor-type warewasher (dishwasher). Door-type (low-volume) and conveyor-type (high-volume) warewashers represent a combined 43% of the market segment of warewashers. Most commercial warewashers are electric, and many use chemicals rather than high temperatures to disinfect, further increasing their environmental impact. Initial estimates indicate that a site will only use one-third of the source energy with a gas warewasher compared to alternative technologies. In this project, researchers and a manufacturing partner modified current electric warewashers, modeling different heat exchanger designs to determine the best-performing configurations that fit into the footprint of an existing electric warewasher. Various prototype heat exchanger(s) were fabricated and put into a prototype unit along with a burner and blower. The team tested a functional prototype for combustion efficiency, safety, and emission standards. Researchers modeled thirteen variations of heat exchanger designs and examined the combustion system in the laboratory with the prototype tank and heat exchanger. The project team used custom controls to tune everything, and the group achieved highly favorable results (under 10ppm NOx). Technicians assembled the burner, blower, and gas valve assembly, along with a new controller for the combustion system. The project group completed the initial testing of the combustion system with the prototype heat exchanger. A follow-on project could be to apply the design to additional models or to prove its performance and reliability in a field test.	
244	82-13	UTD Technical Support to Address Gas	20220622222546	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	8/31/2022	8/31/2024	$5,000	$100,000	$5,000	$0	$0	Active	$0	UTD Members - $95,000	Reliability, Safety, Operational Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	This project aims to provide technical assistance to the commercial food service (CFS) industry to address issues with energy efficiency, environmental impact, decarbonization, cooking performance, and COVID recovery. GTI Energy will continue to represent the gas industry as a part of technical advisory committees, including the NAFEM Technical Advisory committee, ASHRAE CFS Ventilation, Blue Flame Alliance Technical Advisory Committee, and input to SCAQMD CFS low NOx regulations. The project team will also work with CFS manufacturers and end users to provide data and education on the benefits of efficient gas appliances. Some topics GTI Energy will address and participate in include decarbonization through hydrogen blending, energy efficiency, emissions, and ventilation requirements.	
245	82-14	GTI Energy Burner Exchange to Suppor	20200824212953	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	9/1/2020	12/31/2024	$74,999	$1,694,999	$0	$139,999	$0	Active	$0	CEC, UTD Members - $1,620,000	Operational Efficiency, Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	CEC Final Report	The project aims to demonstrate natural gas savings and emission reductions utilizing an advanced radiative recuperator with secondary emitters (RRSE). For this CEC-funded project (PIR-15-006), GTI Energy and the host site, California Die Casting (CDC), modified a furnace to melt aluminum for die casting with an improved RRSE. The RRSE is more efficient and cost-effective than commercially available recuperators, which primarily recover heat from the exhaust gas and preheat combustion air. The project team will couple the RRSE with commercial hot air, ultra-low NOx burners (Bloom 1500S060C) operated with air preheated to as high as 1200ºF. This approach forms a combined heat recovery system that is highly efficient with low NOx. In addition, a stack to preheat scrap on its way to the furnace with exhaust gas leaves the RRSE to increase furnace efficiency further, lowering natural gas demand. The simple payback for this technology is 30 months. The team completed this project but cannot publish the final results until the CEC's final approval.	
246	82-15	GTI Energy Hydrogen Commercial and	20220603205711	Customer End-Use Applications	Commercial Applications		Commercial Applications	9/1/2022	9/1/2026	$752,500	$3,807,500	$396,572	$355,928	$0	Active	$0	CEC, PG&E, UTD, EPRI, OEM, others, In-Kind – Industry Alliances (equipment, engineering) - $3,055,000	Reliability, Safety, Operational Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Foundational Research (Pre-TRL)	CEC Final Report	This project will support the CEC's GFO-21-503 - Examining the Effects of Hydrogen in End-Use Appliances for Large Commercial Buildings and Industrial Applications. The objective is to conduct a technical study of the impacts of utilizing hydrogen, blended with natural gas and 100% hydrogen, in existing appliances and equipment as a decarbonization strategy for large commercial buildings and industrial processes in California. The research aims to identify and resolve key research and technology gaps through techno-economic analysis, laboratory testing and calibrated simulation of representative combustion equipment and materials, air quality modeling, and stakeholder engagement. The focus will be on understanding the cost, performance, and safety implications and the emissions benefits of adopting hydrogen in these sectors. The project team will also identify and address key benefits, challenges, and potential solutions for increasing hydrogen use in end-use equipment. GTI Energy is leading this effort with the Electric Power Research Institute (EPRI) and the University of California, Irvine (UCI) to complete this wide-reaching study. The team will establish a methodology to select equipment categories based on the magnitude of the GHG emissions associated with the type and the potential for reduction via hydrogen use. The techno-economic analysis will seek to understand the decarbonization potential of using hydrogen to fuel these equipment categories and other measures (e.g., energy efficiency) to 2035 and 2050. The team will make a comparison against business-as-usual and alternative pathways (e.g., electrification vs. diversified path).	
247	82-16	UTD Gas Quality Sensor Validation Hyd	20210822225841	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	7/1/2021	2/29/2024	$15,000	$85,000	$15,000	$0	$0	Active	$0	UTD Members, CMR Group - $70,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	This project will broaden the Gas Quality Sensor (GQS) capability to measure gas composition, heating value, Wobbe number, and methane number for natural gases blended with hydrogen. Indicators that the team sees suggest that GQS accuracy will improve when they add a hydrogen detector. The team will add a hydrogen detector to the previously developed GQS and conduct calibration tests in the project's third phase. Phase three will provide data allowing the extension of the GQS capabilities beyond natural gases to hydrocarbon fuel gas mixtures containing hydrogen. The team will give the generated data to the licensee CMR Group, and combining it with their data, will help to accelerate GQS deployment with hydrogen detection capability. The team will conduct testing in the GTI Energy Industrial Combustion Laboratory's Optical lab space. The lab has the needed blending station, mixing system, computer, and data acquisition system. When CMR is ready to ship the GQS unit for testing, GTI Energy engineers will acquire needed calibration gases and set up instrumentation and data collection computers. This work will take a small amount of the team's time and needs to be conducted just before testing the GQS unit.	
248	82-17	UTD Next Generation Infrared Burner -	20220622223333	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	8/31/2022	8/31/2024	$21,400	$180,000	$21,400	$0	$0	Active	$0	UTD Members - $158,600	Safety, Operational Efficiency, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	This project aims to test and optimize the performance of the new gas-fired IR burner that UTD is developing under previous project efforts (2.16.A) in partnership with Solaronics, Inc.- a leading gas-fired IR heater OEM, and a top metal foam material OEM. The goal is to operate on high hydrogen blended natural gas, perform tests on the burner with up to 100% hydrogen, and optimize the design to achieve fast start-up, uniform temperature profile, and ultra-low emissions (i.e., < 5 ppm NOx, < 30 ppm CO). Some key performance indicators include demonstrating stable operation with up to 100% hydrogen, providing comparative analysis in terms of temperature, heat flux, stability, emissions, and turndown capability, and achieving fast start-up, uniform temperature profile, and ultra-low emissions. In 2022, the team performed heat-flux measurements for different conditions and compared them with the performance of traditional IR burners. Researchers reviewed the data from the host site, and these looked promising. The team expects more discussions with the manufacturing partner and the host site, and they will gather additional data.	
249	82-18	UTD Ribbon Burner Performance with	20220622223615	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	8/31/2022	8/31/2024	$20,000	$175,000	$20,000	$0	$0	Active	$0	UTD Members - $155,000	Reliability, Safety, Operational Efficiency, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	This project aims to evaluate traditional ribbon burners' performance when operating with hydrogen and hydrogen-natural gas blends (i.e., 0-100%). The goal is to prove the technical feasibility and identify optimal design performance and design gaps. Some key performance indicators include heat release-temperature profile-emission data in the range of tested conditions and the correlation between hydrogen content in the fuel and test burner performance. The data and correlations obtained will serve as a basis for developing innovative decarbonization concepts that will integrate green hydrogen production, advanced waste heat, and water recovery combined with VOC mitigation and self-powered control.	
250	82-19	EAC H2 Home Appliance Set Validation	20210928235552	Customer End-Use Applications	Residential Appliances		Residential Appliances	12/1/2021	12/31/2024	$137,394	$137,394	$137,394	$0	$41,493	Retired	$0	$0	Environmental: Reduced GHG Emissions, Safety, Reliability, Improved Affordability, Operational Efficiency	Late Stage (TRL 7-9)	Final Report	The SoCalGas Engineering Analysis Center (EAC) conducted validation testing on a set of appliances for deployment at the [H2] Innovation Experience, the first project of its kind in the U.S. aiming to show how carbon-free gas made from renewable electricity can be used in pure form or as a blend to power clean energy systems of the future. The focus of this work was to perform comprehensive equipment validation at the EAC lab with concentrations of hydrogen blended up to 30%. The research team analyzed safety (i.e., flashback, ignition failure, ignition delay, flame profile), emissions, and energy efficiency, which is useful for estimating energy savings. By leveraging the [H2] Innovation Experience, SoCalGas RD&D can field demonstrate a suite of appliances, including a Rinna RU130iN tankless water heater, LG UPSG3014ST Oven Range, and Valor 1700KP fireplace, at up to 20% hydrogen blend. In 2022, the EAC completed its appliance set testing. The equipment was deployed at the [H2] Innovation Experience, which is available for public tours.	
251	82-20	GTI Advanced High Efficiency, Low Cap	2017083043	Customer End-Use Applications	Residential Appliances		Residential Appliances	10/1/2017	12/31/2024	$150,000	$900,000	$150,000	$0	$0	Retired	$0	CEC - $750,000	Environmental: Reduced GHG Emissions, Operational Efficiency, Environmental: Improved Air Quality	Late Stage (TRL 7-9)	CEC Final Report	The goal of this project is the field demonstration and performance testing of advanced high-efficiency, low-capacity heating, ventilation, and air conditioning (HVAC) systems. The team coupled these systems with measures to reduce infiltration and improve building envelopes. The project group outfitted five existing single-family homes with these units and envelope improvements. The aim was to achieve more than 30 percent HVAC energy savings compared to a typical Los Angeles Basin home with standard equipment. The project team produced 24 months of data from five homes in Los Angeles and Orange County. The newly installed equipment had a lower capacity than Title 24 compliant or existing systems, 50% or lower than the equipment in the demonstration homes. The results illustrated the benefits of envelope upgrades and right-sizing the HVAC for homes with improved envelopes. The project team leveraged a combination of utility data analysis and a calibrated BEopt model to prove the potential for HVAC energy savings to be greater than 30%. The project team submitted the final report in November 2021, which they will publish as an official CEC publication. A public webinar was held on August 25, 2021, to share the project findings.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
252	82-21	GTI Hydrogen Blend Burner Design Ana	20210609204322	Customer End-Use Applications	Commercial Applications		Commercial Applications	9/1/2021	6/30/2024	$280,000	$280,000	$70,000	$210,000	$0	Active	$0	$0	Environmental: Reduced GHG Emissions, Safety, Reliability, Improved Affordability	Mid Stage (TRL 4-6)	Final Report	In this project, GTI Energy proposes developing numerical models (i.e., computational fluid-dynamic and reduced-order models) that can quickly simulate different burner types and design variations. The project team will validate the models against experimental data and then use them to 1) identify blending limits with existing burner designs; 2) understand the impact of hydrogen blends on flame stability, burner material durability, and emissions; 3) propose mitigation strategies; and 4) develop industry guidelines for burner designs which expand hydrogen blending limits while maintaining compatibility with natural gas. In 2021, GTI Energy completed the initial literature review of reduced-order models and classic burner design methods. Based on the literature review, GTI Energy is developing a computational fluid dynamic (CFD) model to use as a testbed for different CFD methods to test design theories for fuel-flexible burners. GTI Energy has also begun assembling a list of appliances and burners to test. In 2022, GTI Energy prepared a market survey to understand the types and prevalence of legacy appliances still operating in the SoCalGas service territory. E&W, a consultant assisting with the market survey task, has completed the survey and compiled the results into a draft report issued in late November. GTI Energy is currently reviewing the results with E&W. The team received 27 "good" responses from a combination of homeowners, renters, and property managers. Lastly, GTI has completed testing with the first gas dryer burner identified, indicating no issues with hydrogen blends up to 30% at typical operating conditions. The team has also tested a cast iron boiler burner with up to 30% hydrogen, with no stability or emissions problems observed.	
253	82-22	GTI Strategic Pathways and Analytics Fo	2021091323426	Customer End-Use Applications	Residential Appliances		Residential Appliances	10/1/2021	12/31/2024	$125,000	$1,091,358	$118,098	$6,902	$0	Retired	$0	CEC - $966,358	Safety, Improved Affordability	Late Stage (TRL 7-9)	CEC Final Report	This project will develop a multi-disciplinary and objective analytical framework to identify locations in Southern California where decommissioning can occur in a just, equitable, and cost-effective way. California has some of the most ambitious policies in the U.S. for reducing emissions associated with natural gas use. In some areas, decommissioning natural gas and switching customers to electricity may be a cost-effective approach to meeting these goals. Over time, decommissioning practices of the gas system will greatly impact customers and the gas and electric utilities. Ensuring that socioeconomic equity issues are not exacerbated through decommissioning is paramount. The project team includes an impartial California-based think-tank—the RAND Corp—along with SoCalGas, Southern California Edison, GTI Energy, and LA Regional Collaborative (LARC). The team will combine detailed gas system models with data on candidate communities' socioeconomic conditions to evaluate different decommissioning approaches. The team will work directly with Long Beach and Santa Monica stakeholders in a series of workshops to understand the key needs and concerns of the natural gas customers and then evaluate different decommissioning strategies along with cost, viability, and equity lines. Through these workshops, the team will present specific recommendations for three decommissioning pilot projects and write a set of guidelines and criteria to inform decommissioning of natural gas infrastructure in other areas. In 2022, the project team developed a set of decommissioning scenarios with their engineering teams. They are performing detailed engineering analyses to understand the impacts of decommissioning different portions of the system in Santa Monica.	
254	82-23	ORNL Hydrogen Fueled Cooking Equipn	20200725232713	Customer End-Use Applications	Residential Appliances		Residential Appliances	10/1/2020	12/31/2024	$400,000	$930,000	$400,000	$0	$0	Retired	$0	DOE, In-kind - Samsung (equipment) - $530,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Improved Affordability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report	The objective is to develop clean, reliable, and safe residential cooking appliances equipped with catalytic oxidation burners capable of operating on 100% hydrogen and natural gas blends (up to 50% hydrogen) while producing zero NOx. In this project, the team will retrofit a residential cooking range and oven with flameless radiant burner technology for testing in the lab. This technology has many advantages, such as emissions reduction, wide turndown, safety, and operation with lean mixtures beyond flammability limits. In 2021, the project made progress toward designing and specifying a prototype. The team evaluated preliminary burner designs for different operating scenarios. The team worked with several manufacturers to fabricate the early-stage prototype design, and the project team issued a purchase order at the end of the year. In April 2022, a prototype burner was manufactured and tested with hydrogen and natural gas blends. In June 2022, the team fabricated the finalized design of burners for full system integration on a Samsung residential cooktop. In September 2022, the team installed hydrogen-compatible burners in the cooktop. Comprehensive performance testing on the cooktop using hydrogen and natural gas blends began in September, and the team completed it before the year-end. ORNL will issue a final project report and press release in the second Quarter of 2023.	
255	82-24	UCI Catalytic Burner Retrofitted Water	20200716215134	Customer End-Use Applications	Residential Appliances		Residential Appliances	9/1/2020	12/31/2023	$410,000	$435,000	$114,999	$295,001	$0	Retired	$35,000	In-Kind - AO Smith, Alzeta, American Catalytic (equipment) - $25,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	Final Report	This project is a follow-up to a previous project that identified several viable flameless radiant burners that the industry could retrofit to achieve near-zero NOx emissions from commercially available water heaters. While these burners have existed for some time in different applications, they have yet to be installed into water heaters. Thus, for comparison, several burner configurations will be procured and deployed in water heaters. The team will assess the performance of the retrofitted water heaters (I.e., ignition performance, efficiency, emissions, and tolerance to hydrogen content). The study will compare the results to the legacy burner technology commonly found in water heaters. The relative tolerance to hydrogen content will also be evaluated, providing insight into how these burners can help reduce carbon emissions from natural gas with hydrogen blends. In 2021, the University of California, Irvine (UCI) procured and designed one of three burner technologies they plan to develop as a retrofit kit for commercially available water heaters. They completed the first batch of preliminary tests on the first burner design. In 2022, the research team completed their initial performance, emission, and safety evaluation while beginning the design process of integrating the catalytic burner into a full-scale system.	
256	82-25	UTD Boostheat Thermal Compression-(	2021022503118	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2020	6/3/2024	$26,667	$225,000	$26,667	$0	$0	Active	$0	UTD Members, OEMs - $198,333	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Safety, Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The objective of this project is to develop a North American thermal heat pump (THP) with a focus on 1) a high modulation ratio, 2) integration with forced-air distribution, and 3) adding cost-effective cooling. Project partner BOOSTHEAT has recently established an innovative and new business model in Europe. To successfully enter the North American market, however, this UTD project will address key product development needs. THPs have significant potential for 20% or greater improvement in energy savings and emissions reductions versus best-in-class conventional sorption and vapor compression-type THPs. The project team completed laboratory preparations for testing the BH.20 using a Virtual Test Home (VTH) protocol. The test infrastructure is complete, and the remainder of the activity focuses on data acquisition and control setup. The test apparatus is undergoing shakedown to test a different heat pump before the arrival of BOOSTHEAT's unit. BOOSTHEAT experienced a production delay in 2020-2021 for various reasons. The company addressed key technical challenges and consolidated staff under a single roof. In early 2022, the company indicated that their new units' reliability and performance had improved. BOOSTHEAT is also re-developing the packaging and controls of the thermal compressor so that the BH.20 can provide both space heating and domestic hot water. BOOSTHEAT expects to make a unit available for testing and additional technical refinement (including using a VTH protocol) in the first quarter of 2023.	
257	82-26	UTD Gas Engine Heat Pump Modeling,	2022062222053	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/31/2022	8/31/2024	$5,900	$180,000	$5,900	$0	$0	Active	$0	UTD Members - $174,100	Operational Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	This project aims to demonstrate the recently-introduced Yanmar Air Handling Unit (AHU) Integration Kit at a cooling-demonstration site to validate performance and savings in life cycle costs. The AHU kit pairs a high-efficiency gas engine-driven heat pump (GEHP) to a packaged rooftop air handling unit to apply GEHPs to a broader range of commercial buildings and minimize installation costs. A successful demonstration of the AHU kit will support a high-efficiency and cost-effective role for natural gas in commercial buildings for cooling-dominated climates. Some key performance indicators are to obtain at least 12 months of field data, achieve a seasonal coefficient of performance (COP) > 1 for both cooling and heating performance, and publish results in the technical paper and conference presentation. The project team compared hourly measured field data on the heating and cooling performance with the limited laboratory test data on the same unit. In 2022, the group held regular meetings with the National Research Council Canada staff and Yanmar Co., Ltd. to collaborate on GEHP model development and share performance data.	
258	82-27	UTD Hydrogen Blending End-Use Perfo	20220622221254	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/31/2022	8/31/2024	$16,000	$450,000	$16,000	$0	$0	Active	$0	UTD Members - $434,000	Safety, Operational Efficiency, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	This project intends to demonstrate blended hydrogen gas's safety, technical, and performance implications from an end-user perspective in a simulated neighborhood. The project aims to 1) measure the end-user performance and safety impacts of a wide array of fuel-fired equipment (e.g., HVAC, water heating, cooking), 2) quantify the efficacy of in-field retrofits and mitigation strategies for individual appliances, and 3) estimate the decarbonization potential of hydrogen blending through population modeling. In coordination with Southwest Gas, the project team seeks to leverage their utility training facility in Henderson, NV, as a hydrogen-blended equipment demonstration and outreach platform. The project will leverage the site's existing plans to install and operate an on-site electrolyzer to blend hydrogen at a variable rate into an islanded distribution network serving the training facility. The 15 homes within the simulated neighborhood will house the experimental equipment.	
259	82-28	UTD Hydrogen-Blended Gas in ResCom	2022062221486	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/1/2022	8/1/2024	$10,000	$150,000	$10,000	$0	$0	Active	$0	UTD Members - $140,000	Safety, Operational Efficiency, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	This project intends to support the potential deployment of up to 30% hydrogen blended gas in North American buildings. The team will assess the performance, emission, safety, and quality impacts of hydrogen mixing on widely used but low-load peripheral gas appliances such as gas lights, space heaters, outdoor fire pits, and indoor fireplaces. Specifically, the project team aims to determine the impacts and limits of hydrogen blending on these gas systems, assess qualitative results on aesthetic combustion equipment, and recommend changes for improved compatibility and performance. In 2022, test stands were built and modified for standardized testing of furnaces and water heaters. The team completed a preliminary literature review on relevant test and certification methods. The research team developed a comprehensive test plan, with testing expected to occur in the third or fourth quarter of 2022. As part of the R&D road mapping and outreach efforts under this project, the team prepared a summary paper for the World Gas Conference held in May 2022. Researchers demonstrated that methane emissions decrease with added hydrogen. The response to results was very positive, particularly with high interest from organizations in Latin America. There are several emerging options for distributed gas quality and hydrogen sensors. The project team is meeting with representatives from several sensor manufacturers.	
260	82-29	UTD Next Generation Residential Gas D	202101223436	Customer End-Use Applications	Residential Appliances		Residential Appliances	7/1/2020	7/31/2024	$28,000	$160,000	$28,000	$0	$0	Retired	$0	UTD Members - $132,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The goal is to find a technology to achieve a 5-15% edge over standard efficiency gas dryers. In this project, researchers are investigating next-generation gas dryer technologies to exceed EnergyStar efficiency levels. They developed an early-stage prototype with promising technology. Phase 1 of this project focused on assembling a test station in an environmental chamber to maintain temperature and humidity to make certain accurate testing. In Phase 2, researchers investigated additional heat-recovery options, modulation techniques, indirect-fired methods, direct venting, and alternative burners. Testing at four firing rates consistently showed around a 2% improvement with lower firing rates. The dryer was insulated and sealed to test potential boost from fewer leaks and allow heat recovery implementation. After several variations, technicians achieved a 5%-6% increase in insulation and sealing efficiency and a 6% reduction in drying time. The insulation and sealing also allowed researchers to implement an innovative heat-recovery design. Any proprietary technologies discovered during the project will result in a UTD invention disclosure. In 2022 under Phase 3, the team built an environmental chamber to perform a subsequent product development and testing round. Researchers are awaiting the completion and availability of a new test chamber to complete	
261	82-30	UTD Residential Gas Absorption Heat P	20200401223018	Customer End-Use Applications	Residential Appliances		Residential Appliances	7/1/2019	6/28/2024	$42,491	$170,000	$42,491	$0	$0	Retired	$0	SMTI, UTD Members - $127,509	Environmental: Reduced GHG Emissions, Improved Affordability, Reliability, Operational Efficiency	Late Stage (TRL 7-9)	N/A	This project builds upon a gas-fired heat pump water heater (GHPWH) developed and supported in conjunction with UTD Project 1.11.H, scaling up the same absorption heat pump technology by an eight-fold factor. The objective of this project is to support the development of next generation GHPWH by eliminating a major cost hurdle for some installations and enhancing reliability and efficiency diagnostics. One effort was to reduce the installation cost/barrier of condensate drain by developing a proprietary method of neutralizing, collecting, and disposing of combustion condensate where access to a sanitary sewer drain is otherwise cost-prohibitive and improving the onboard diagnostics by exploring the use of Enhanced Solution Level Control (ESLC) which can improve system reliability and long-term performance. Using the experience of 12 demonstrations of Phase 1 to 4 GHPWH precommercial prototypes, GTI and SMTI have identified typical conditions and root causes of poor efficiency and/or product failure. In July 2021, it was announced that UTD member Enbridge had invested CAN $4,000,000 in the late-stage start up SMTI, the developer of the technology advanced in this and other UTD projects. The project team is finalizing preparations for installation of GAHP hybrid equipment in the laboratory, with thermal heat pump test station upgrades. Researchers are analyzing the results of testing to make recommendations on system design modifications, sizing considerations, and controls updates.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
262	82-31	UTD Residential Gas Absorption Heat P	2021091604315	Customer End-Use Applications	Residential Appliances		Residential Appliances	7/1/2020	8/31/2024	$15,000	$200,000	$15,000	$0	$0	Retired	$0	UTD Members - $185,000	Environmental: Reduced GHG Emissions, Environmental: Improved Air Quality, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	This project was based upon a gas-fired heat pump water heater (GHP-WH) developed and supported in conjunction with UTD Project 1.11.H. This project aims to scale up the same absorption heat pump technology by a factor of eight. The objective is to support the development of the next-generation GHP-WH by eliminating a major cost hurdle for some installations, along with enhancing reliability and efficient diagnostics. One effort is to reduce the installation barrier and cost of a condensate drain by developing a proprietary method of neutralizing, collecting, and disposing of combustion condensate. This aspect benefits users where access to a sanitary sewer drain is otherwise cost-prohibitive. Also, the team can leverage Enhanced Solution Level Control (ESLC) to improve the onboard diagnostics, which can enhance system reliability and long-term performance. Using the experience of 12 pre-commercial GHPWH prototypes tested in demonstrations conducted in Phases 1 to 4, GTI Energy and Stone Mountain Technologies, Inc. (SMTI) identified typical conditions, root causes of poor efficiency, and product failures. SMTI is the developer of the technology advanced in this and other UTD projects. Technical tasks under Phases 5 and 6 improved the final design and fabrication of test setups to evaluate the proof of concept of the liquid level sensor (LLS) platform and the de-condensation idea. For Phase 6, the team completed an agreement with SMTI to produce a next-generation alpha prototype GHPWH. SMTI delivered the updated unit in the fourth quarter of 2022. Researchers concluded the Phase 6 test plans and fabricated prototypes of additional features.	
263	82-32	UTD Safe Use of Hydrogen in Buildings	20220622221943	Customer End-Use Applications	Commercial Applications		Commercial Applications	8/31/2022	8/31/2024	$10,000	$150,000	$10,000	$0	$0	Active	$0	UTD Members - $140,000	Reliability, Safety, Environmental-Reduced GHG Emissions	Mid Stage (TRL 4-6)	N/A	The purpose of this project is to enable the broad deployment of hydrogen-blended gas by proactively addressing consumer and regulatory concerns about its safe use in buildings. This project will characterize the propensity of hydrogen in blends with natural gas to preferentially leak from existing building gas distribution systems and appliance gas handling subsystems. This project also aims to address barriers to the safe use of higher hydrogen blends greater than 30% in residential and commercial appliances. Some key performance indicators are 1) quantifying leakage of hydrogen blended gas compared to natural gas from standard fittings, 2) identifying design requirements for high hydrogen blend operation (i.e., 40-100%), and 3) publicly disseminating findings and recommendations through peer-reviewed publications and webinars. In 2022, GTI Energy kicked off the project with a literature review into prior research on preferential hydrogen leakage from low-pressure gas distribution systems and fundamentals of detonation wave formation for mixtures of methane and hydrogen. GTI Energy is also working on installing and configuring Converge computational fluid dynamics (CFD) software which will be used to analyze detonation wave formation.	
264	82-33	UCI Low NOx Water Heater Retrofit for	2020072501614	Customer End-Use Applications	Residential Appliances		Residential Appliances	9/30/2020	5/30/2023	$241,468	$273,468	$241,468	$0	$108,674	Completed	$0	Rheem - $32,000	Reliability, Safety, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	Final Report	The project's objective was to take existing low NOx water heaters and improve the operational limits of hydrogen tolerance. The project's goals were to evaluate the modifications that would allow adding additional hydrogen, to carry out the improvements, and to demonstrate the amount of additional hydrogen that could be blended and allow reliable operation. The team did laboratory testing to evaluate general observations, ignition, flashback, and efficiency. In addition, the team quantified emissions to understand how the NOx, carbon monoxide, and unburned hydrocarbon (UHC) levels change with increased hydrogen addition. In 2021, the team evaluated, baselined, and proposed several modifications to the water heaters they received. Some methods they used to assess the water heaters included thermal imaging of the burner top to understand the temperature distribution, thermocouples to measure the surface temperature, and fuel control to vary the hydrogen-natural gas mixture. In 2022, the team completed the initial testing of their appliance set. The research team focused on design modifications to improve the hydrogen tolerance of the burners and is evaluating those modifications under comprehensive safety, performance, and emissions testing. A journal publication was released on 3/3/2023. https://www.sciencedirect.com/science/article/pii/S036031992300722X.	
265	82-34	UTD Accelerated Life Testing of ResCom	20231018182617	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$150,000	$0	$0	$0.00	Active	$0	UTD Members - $135,000	Safety, Reliability, and Reduced GHG Emissions	Mid Stage (TRL 4-6)	N/A	This project aims to evaluate the performance of non-burner components in residential and commercial combustion devices with hydrogen-blended gas. The results will inform gas stakeholders about the potential issues of using hydrogen in gas networks. The key performance indicators of success are a report that lists the compatibility or degradation of each component when exposed to H2, a set of recommended strategies to address any problems identified by the report, and a publication in a peer-reviewed journal or conference proceedings that details the findings and methods of the project, and the compatibility problems that were or were not found. The project will also produce the following deliverables: component compatibility or degradation reports, problem mitigation strategies, and peer-reviewed publications of findings and methods. The primary target markets impacted by this project are standard gas equipment used in appliances, such as valves, regulators, tubing, etc., and residential, commercial, and industrial combustion equipment designed for natural gas.	
266	82-35	UTD Advanced Controls for Residential	20231018183536	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$200,000	$0	$0	$0	Active	$0	UTD Members & PERC - $190,000	Operational Efficiency, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	This project aims to address indoor air quality (IAQ) issues related to residential cooking by developing better ventilation control systems to improve IAQ, save energy, and reduce carbon footprint. The main tasks of the project are as follows. First, evaluate novel advanced controls for demand-controlled kitchen ventilation systems. Second, monitor energy input to cooking appliances and local IAQ. Third, develop appliance control panel logic that can adjust ventilation flowrate and identify issues with the appliance. Fourth, evaluate hood performance during modulation and measure capture efficiency using a shadowgraph system. The key performance indicators to measure the project's success include a 30% improvement in capture effectiveness compared to standard ventilation hoods, a 10% reduction in conditioned air losses compared to standard ventilation hoods, and energy savings through winter and summer heating and cooling loads. The deliverable for this project will be a quick response control system that can automatically modulate the ventilation rate based on the cooking activity and the appliance energy measurement method that can monitor the energy consumption of the cooking appliances.	
267	82-36	UTD CFS Burner Technology Carbon Re	2023101818318	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$150,000	$0	$0	$0	Active	$0	UTD Members - $122,000	Operational Efficiency, Environmental-GHG Emissions	Mid Stage (TRL 4-6)	N/A	The project aims to determine the potential decarbonization of commercial foodservice (CFS) appliances when using 100% hydrogen or blends of up to 30% hydrogen in natural gas. Phase 3 will focus on full appliance testing and cooking performance impacts and will build on the testing of standalone burners and controls in Phase 1 and appliances in Phase 2. GTI, through its contacts at NAFEM (North American Foodservice Equipment Manufacturers), will work with CFS manufacturers to identify and supply appliances for testing. 100% hydrogen appliances will come from outside North America. Specific tasks to complete include testing a 100% hydrogen fryer from Falcon and a grill from Heatlie, expanding existing appliance blend tests with a to-be-determined manufacturing partner, and determining if cooking with hydrogen or hydrogen blends causes degradation of cooking utensils. Some key performance indicators to measure the success of Phase 3 will include the results of testing the 100% hydrogen fryer and grill, performance data for up to five CFS appliances from these equipment types with hydrogen and hydrogen-enriched natural gas (measuring efficiency and emissions such as O2, CO2, CO, NOx, and evaluating cooking performance and flame appearance) and communicating findings to CFS manufacturers. The deliverables for this project will be data, calculations, and experimental test results that support the decarbonization of CFS appliances using hydrogen blending. The results will show if hydrogen or hydrogen blending harms combustion performance, cooking performance, and safety.	
268	82-37	UTD CFS Decarbonization Tool Develop	20231018183211	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$125,000	$0	$0	$0	Active	$0	UTD Members - $119,643	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The goal of this project is to demonstrate and promote the value of efficient, clean, burning gas-fired cooking equipment and advanced Commercial Foodservice (CFS) equipment to the CFS industry. The project will modify demonstration tools with Hydrogen-blended gas and source-based energy calculations. The project will measure its success by quantifying the benefits of natural gas (NG) and NG/Hydrogen blends in high-efficiency gas-fired CFS appliances, including calculating carbon footprint improvement and energy savings. The modification of Foodservice Energy Monitoring System (FEMS) Software to show the carbon footprint, source efficiency, and source emissions for electric, natural gas, and NG/hydrogen blended CFS appliances. The tool will then be able to provide a source-based total impact of tested appliances as they are cooked live and provide lifecycle cost savings and payback periods for any location across the country. The installation of FEMS capability at one utility test kitchen and the conduct of a live cooking demo with updated FEMS and NG/H2 to show the large carbon reduction capability of high-efficiency gas-burning CFS equipment. The team will compare the performance, food quality, and quantity with electric appliances. The project will provide the following deliverables: updated FEMS Software with source-based energy use, emissions, and carbon impact and expected lifecycle payback for both NG and NG/H2; installation at one utility test kitchen; and a demonstration of software cooking on high-efficiency CFS appliances with both NG and NG/hydrogen as well as electric appliances.	
269	82-38	UTD CleanO2 CarbinX Carbon Capture	20231018181924	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$220,000	$0	$0	$0	Active	$0	UTD Members, CleanO2 - $206,400	Improved Affordability, Environmental-Reduced GHG Emissions	Mid Stage (TRL 4-6)	N/A	The objective is to develop and test CleanO2's next-gen commercial carbon capture unit, CarbinX v. 4, focusing on condensing appliances. The aim is to achieve a carbon capture efficiency of ≥50% and a payback period of ≤5 years. Key Performance Indicators include compatibility with natural gas and propane condensing appliances, the effectiveness of the new cartridge design, and optimal waste heat recovery. The results will be published in a technical paper or conference presentation. Phase 2 of UTD 1.21.C will further validate the importance of distributed carbon capture technology within buildings, guiding the technology developer towards a product that can decarbonize a wider range of water heating appliances, including natural gas and propane-fired boilers. The primary markets for CleanO2's carbon capture technology are residential and commercial buildings, including multifamily homes, assisted living facilities, hotels, schools, offices, shopping malls, and commercial boilers with a capacity between 250 and 1,500 MBH. The technology aligns with UTD's goals to save consumers money and reduce GHG emissions. The current version reduces GHG emissions by 20%, with a target of 50% reduction for the next-gen v.4 unit and eventually 100% for future technology. The payback for the carbon capture unit based on average usage is approximately six years. With CleanO2's next-gen v. 4, rebates could potentially be multiple times that of the current technology iteration, significantly reducing the payback period.	
270	82-39	UTD Combustion Technology for Emer	20231018182440	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$225,000	$0	$0	$0	Active	$0	UTD Members - $189,720	Reliability, Safety, Operational Efficiency, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The objective of this project is to conduct a comprehensive evaluation of equipment that is already designed or being operated with manufactured gases in markets outside North America. The primary focus of this evaluation is on water heating and cooking applications, including performance and reliability tests. The goal is to identify key principles that can be applied to the types of natural gas-certified equipment typically sold in North America. In addition, a safety and technical review of emerging low-carbon manufactured gases used in various applications such as water heating, cooking, and space heating will also be conducted. These manufactured gases can include hydrogen blended with natural gas and emerging methane substitutes or hydrogen carriers such as ammonia, liquid-organic hydrogen carriers (LOHCs), and renewable hydrocarbons like bio-propane and rDME. Several Key Performance Indicators will gauge the success of the project. These include creating a list of appliances using manufactured gas across global markets and identifying the design modifications typically employed in these appliances for them to function with manufactured gases. The project will also involve testing appliances, developing performance data for appliances with hydrogen blended into natural gas, and identifying opportunities for technology and safety transfer to North America. This approach includes six water heaters and six ranges/cooktops. Lastly, a safety and technical review of emerging manufactured gas impacts beyond H2 will be conducted.	
271	82-40	UTD Controlled Mixing Burner for Proc	20231018192236	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$305,000	$0	$0	$0	Active	$0	UTD Members - $296,400	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project's objective is to design, build, and test a laboratory prototype version of an innovative 0.5-1 million Btu/hr process heating burner for natural gas and alternate low-carbon fuels (LCFs). This approach will enable adopters of LCFs in process heating applications to use varying amounts of LCFs in their fuel streams, including up to 100% carbon-free fuels (CFFs) such as H2 and NH3. The project aims to demonstrate through laboratory testing that the flame size and shape, heat release profile, emissions, and turndown capability remain unchanged, irrespective of fuel carbon content. The team will test the prototype under different furnace temperatures, % carbon in the fuel, and other simulated operating conditions to assess the applicability of the technology to key end users as they seek to decarbonize operations. Key Performance Indicators for project success include achieving less than 25% change in flame length, NOx emissions, and peak heat release distance for 0 to 100% H2 or NH3 blended in natural gas. The burner should maintain a 4:1 turndown and less than 50 ppm CO with no stability, ignition, or flame sensing issues. The burner's estimated cost and control complexity should be comparable to conventional burners. The project also aims to obtain an expression of interest from a major burner manufacturer to partner on the next stage of development/scale-up and support commercialization planning.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
272	82-41	UTD Deep Energy Customized Affordab	2023101818217	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$2,014,714	$0	$0	$0	Active	$0	UTD Members, DOE, Syracuse University, Hydronic Shell Technologies - $2,014,714	Operational Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions	Mid Stage (TRL 4-6)	N/A	The project aims to develop and test innovative mechanical equipment in GTI Energy's laboratory. This equipment will build upon the work under Phase 1, which focuses on developing and demonstrating innovative residential building envelope improvements, particularly deep energy retrofits and related equipment. The project will involve additional modeling and validation of the Hydronic Shell mechanical distribution system, testing Navien's new Hydro-furnace low-load single-family mechanical system retrofit, and assessing its fit with the Hydronic Shell. It will also involve developing an integrated gas-fired HVAC pod concept with space conditioning, ventilation, and potentially battery-electric storage to leverage the end-user benefits of the resilient gas distribution system. The overall goal is to integrate next-generation, high-efficiency, fuel-fired space conditioning equipment to show the continued use of fuel-fired equipment in Net Zero Buildings. Key performance indicators of success include demonstrating that a lab-tested pre-prototype of hydronic retrofit panel can maintain indoor comfort and provide efficient heating distribution for gas heat pumps (GHPs), achieving a +50% GHG reduction in at least two different integrated envelope + HVAC retrofits, submitting a modeling library item to EnergyPlus, assessing the fit of Navien's new Hydro-furnace with Hydronic Shell technology, and creating a conceptual design of a fuel-fired mechanical pod. Phase 2 of this "DECARB-EM" project leverages prime funding by NYSERDA in Phase 1, as well as potential prime financing from the U.S. DOE. UTD project 1.22.E also builds upon long-standing work by UTD under earlier project 1.11.M on residential retrofits through the US Department of Energy's Building America Research Program.	
273	82-42	UTD Emerging Distributed Methane Py	20231018182319	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$170,000	$0	$0	$0	Active	$0	UTD Members - $157,327	Reliability, Operational Efficiency, Environmental-Reduced GHG Emissions	Mid Stage (TRL 4-6)	N/A	The objective of the project is to combine application/process with end-user demand modeling to classify a range of emerging distributed methane pyrolysis solutions as good, better, or best. The project team will achieve this through expanded outreach to the primary technology developers in this space, such as Modern Electron, and building on the Phase 1 effort to complete a survey of options for distributed methane pyrolysis technologies. This approach includes a techno-economic assessment (TEA) over various applications, treating the underlying conversion process, hydrogen end uses, and handling carbon outputs. Key performance indicators for Phase 2 project success include refining and executing the distributed methane pyrolysis application and process modeling plan, including scenarios in the Phase 1 TEA. Based on the process and building energy/industrial process modeling results for select applications/technologies, recommendations or follow-up proposals will be provided for UTD to advance specific technologies in good/better/best fits by end-use. The project team will complete a final TEA of distributed methane pyrolysis solutions, including at least five H2 end-use scenarios and five or more carbon output scenarios. Information and data will also be gathered regarding pilots and scale-up efforts of distributed methane pyrolysis technologies running in parallel. Over Phases 1 and 2, the project team will summarize data collected and modeling results to make recommendations to advance the technologies.	
274	82-43	UTD Energy Recovery from Brewing-Di	2023101819170	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$1,470,000	$0	$0	$0	Active	$0	UTD Members, CEC - $1,460,000	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project aims to analyze the benefits of the Waste Heat Effective Technology (WHET) for waste heat recovery and energy efficiency in potential markets such as commercial laundry operations, agriculture, and food processing. This approach extends beyond the brewery and distillery markets currently being addressed in UTD 2.21.B, which received prime funding from CEC. The project team will leverage the experience, system designs, and data collected during the field evaluation at two demonstration sites to identify the most promising additional markets for the WHET approach. It will also explore potential interest in this technology from these other markets to accelerate development and supplement a Technoeconomic Analysis performed under GTI Energy's contract with CEC. Key Performance Indicators (KPIs) for project success include a summary of WHET market applications beyond the brewery and distillery markets, assessing market size and energy savings potential, and process analyses for promising WHET applications, including sample layouts, capital costs, and operating costs. In 2023, the second demonstration site was forced to close. The team found a replacement demonstration site. The team worked with local contractors and completed the installation process for the second installation during the third quarter of 2023. Baseline testing has been achieved at the second site, and both sites are now in demonstration mode. The project team will monitor the demonstration systems' performance for a minimum of 12 months.	
275	82-44	UTD Energy Source Options for Industr	20231018191457	Customer End-Use Applications	Industrial Process Heat		Industrial Process Heat	7/1/2023	7/31/2025	$0	$200,000	$0	$0	$0	Active	$0	UTD Members- $189,600	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The objective of this project was to provide a robust, user-friendly analytical tool that can help decision-making, which will drive decarbonization and achievement of local environmental targets. As these end-users actively pursue reliable and cost-effective energy supply that meets environmental targets, the tool aims to provide a robust, user-friendly solution that offers clear guidance for decarbonization efforts. Key Performance Indicators of success include the incorporation of key gas-fueled industrial applications (such as furnaces and ovens) that are currently being actively proposed for electrification, scoring the decarbonization potential and economic impact related to these applications, and providing a simple user interface with clear, supportive material for easy understanding and usefulness for UTD members and customer evaluations. Phase 3 of the project will build on the results from the previous two phases. Phase 1 developed a spreadsheet-based tool, while Phase 2 transitioned the tool to an initial online version for industrial boilers. Phase 3 aims to expand to other industrial applications and further streamline the user interface and supportive materials. In 2023, the team started working to develop the tool to include furnaces and ovens as part of Phase 3.	
276	82-45	UTD Flex Fuel Gas Nozzle and Burner fo	20231018192323	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$350,000	$0	$0	$0	Active	$0	UTD Members - $302,600	Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project aims to design and build a 500,000 Btu/h laboratory prototype version of the flex fuel nozzle, retrofit it to an existing commercial burner at GTI, and test its flame flexibility characteristics on natural gas and an analog for alternate low carbon fuels (LCFs) such as renewable energy-derived fuels and hydrogen under simulated boiler conditions. The goal is to demonstrate that wide variations in flame size and shape can be made through on-the-fly positioning of the nozzle components. The team will test the nozzle to assess the applicability of the technology to different boilers and select process heating burners to optimize performance with both natural gas and alternate LCFs. It will also develop designs for a 3-5 million Btu/h nozzle and burner. Key Performance Indicators (KPIs) for project success include confirmation through CFD modeling that flame length and girth can be changed by at least 2:1 by fuel nozzle adjustments, validation of CFD results demonstrating the same flame length and girth can be achieved with 300 – 1000 Btu/SCF fuel with no change in air pressure drop, and maintaining a 4:1 turndown and <50 ppm CO with no stability, ignition, and flame sensing issues. Incorporating the flex nozzle should not significantly increase the design and operation complexity of the burner, and the nozzle and associated adjustment drives should add less than 20% to the cost of the burner and controls. The project also aims to pursue a US patent application and obtain an expression of interest from a major burner manufacturer to partner on the next stage of development/scale-up and support commercialization planning.	
277	82-46	UTD Hydrogen Flame Visibility and Colo	20231018182924	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$150,000	$0	$0	$0	Active	$0	UTD Members - $116,666	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project aims to evaluate and identify colorants for hydrogen-enriched gaseous fuel under various conditions. The objectives include establishing a matrix of hydrogen/methane mixtures to test visibility from 0% to 100% hydrogen and enhancing the safety of open-flame operation of hydrogen-enriched natural gas under four common lighting conditions with appropriate and safe gas colorants. Using gaseous colorants can allow the hydrogen/natural gas fuel to mimic natural gas flames, addressing safety concerns from gas end users regarding the appearance of hydrogen-enriched flames. Key Performance Indicators of success include assessing the flame visibility of hydrogen-enriched fuels from 0% up to 100% hydrogen addition and establishing a flame appearance map, conducting hydrogen combustion and visibility tests under at least four lighting conditions, and identifying at least two non-toxic and non-corrosive gaseous flame colorants that can be safely added into the gas transmission and storage infrastructure while enhancing hydrogen flame visibility. The project also aims to publish the results in a peer-reviewed journal or conference proceedings, demonstrate the colorant application with a manufacturing partner to develop the technology further and evaluate on a conceptual basis how a colorant might be added to a gas distribution network.	
278	82-47	UTD Impacts of Hydrogen-Blended Gas	20231018182723	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$150,000	$0	$0	$0	Active	$0	UTD Members - $134,800	Reliability, Operational Efficiency	Mid Stage (TRL 4-6)	N/A	The project aims to assess how blending hydrogen at up to 30% and possibly higher in natural gas may impact the compliance of existing gas appliances with the National Fuel Gas Code, NFPA 54, and other key related global standards, guidelines, and building codes for flue gas venting, condensate management, and weatherized equipment. Key performance indicators for success include laboratory testing of at least three appliances or classes of appliances to identify the leading venting construction and design factors that impact good and bad combustion outcomes and flame characteristics. Factors may include vent diameter, height, length, input rate, and environment. The project also aims to develop vent tables similar to those in section 13 of NFPA 54/ANSI Z223.1 for the range of tested hydrogen blended gases and publish the results in a technical paper or a release of this project's Final Report. This project builds upon key Codes and Standards such as NFPA 54/ANSI Z223.1, the National Fuel Gas Code safety requirements for appliance installation and operation, fuel gas piping and venting systems in homes and other buildings, and applicable ASHRAE Standard requirements, forums, seminars, and research projects.	
279	82-48	UTD Inherently Safe ResCom Combusti	20231018182826	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$175,000	$0	$0	$0	Active	$0	UTD Members - $145,526	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project aims to ensure customer gas appliances' safe, reliable, and efficient operation with H2-blended gas (5-50% H2 by volume). The project team will achieve this by developing and demonstrating inherently safe combustion systems for common gas appliances such as furnaces, water heaters, and ranges and identifying inexpensive options to retrofit typical existing appliances. This approach will assist gas utilities in demonstrating hydrogen blending levels well above 5% by volume and broadly deploy blended gas in their networks. Key performance indicators of success include practical, economical combustion system designs for new and retrofit applications that can either prevent flashbacks, detect flashbacks, or shut down the burner safely. The project team will demonstrate the technology in at least three common gas appliances in a laboratory setting. The team will publish the results in peer-reviewed journals or conference proceedings and file a provisional patent(s) application. The project also aims to obtain an expression of interest from a manufacturing partner to develop further and demonstrate the technology. This project will build on prior GTI Energy research under earlier UTD-funded research, UTD 1.20.H Phases 1-3, and other industry-funded projects to investigate the limitations of blending hydrogen with natural gas in typical North American appliances.	
280	82-49	UTD Low Emission Efficient Burner for	2023101819103	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$150,000	$0	$0	$0	Active	$0	UTD Members - $146,600	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project aims to design, build, and factory-test an innovative 3D-printed, UTD-patented burner at 3 MMBtu/h capacity for air heating applications such as ovens and dryers with natural gas (NG). Phase 3 will focus on installing a commercial prototype in a factory location. The technology has the potential to significantly reduce NOx and CO emissions, reduce blower requirements, and increase efficiency. Key Performance Indicators for Phase 3 success include demonstrating high efficiency, stable ignition, and combustion characteristics, low NOx and CO emissions, high turndown, and stable, robust operation in crossflow air in service. The overall performance is a critical proof point to convince the manufacturing partner to take the next steps to offer a commercial product. Phase 3 will build on GTI's successful previous efforts in Phase 1 with Preheat to develop the design of a burner capable of operating efficiently and robustly for process air heating applications. Before installation at the factory host site in Phase 3, final burner testing may also be performed on the process air heater testing facility at GTI. Phase 2 is testing the performance of this innovative burner with H2-blended gas. In 2022 and 2023, an improved second prototype burner design was fabricated based on further computational fluid dynamics analysis. When tested on natural gas, it demonstrated operation at up to 6:1 turndown, very low CO emissions of below 10 ppm over the entire range of firing rates, robust ignition and stable flames, and superior NOx performance. The team completed performance testing of both prototype designs with < 9 ppm NOx (corr. to 3% O2) and < 10 ppm CO (corr. to 3% O2) emissions achieved.	
281	82-50	UTD Next Generation Commercial and	20231018183647	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$200,000	$0	$0	$0	Active	$0	UTD Members - $186,400	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project aims to work with commercial and residential range manufacturers to commercialize advanced range burner designs developed during the current UTD project (1.17.H Residential Cooking Indoor Air Quality – Phase 4) for cooking with natural gas and propane. Potential partners include several leading manufacturers. Key performance indicators for success include incorporating the new burner design in prototype commercial and residential ranges that demonstrate a 20% improvement in energy efficiency and a 75% reduction in NOx emissions. Performance testing will be completed in partnership with one or more leading OEMs.	

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1	No.	Project Title	Project Number	Program	Sub-program	2022 approved new sub-program	Research Area	Start Date	Anticipated End Date	SCG Budget	Total Project Cost	Amount Already Spent	Amount Still to be Spent	Actual Incurred Costs Jan-Nov '23	Status	Estimated Incurred Costs Jan-Nov '23	Co-funders & Co-funding contribution	Project Benefits	Technology Readiness Level	Anticipated Next Steps at End of Project	Project Description	Hydrogen Blending Projects
282	82-51	UTD Technical Assistance to Advance G	20231018183342	Customer End-Use Applications	Commercial Food Service		Commercial Food Service	7/1/2023	7/31/2025	$0	$120,000	$0	$0	$0	Active	$0	UTD Members, PERC - $104,000	Reliability, Safety, Operationaly Efficiency, Improved Affordability, Environmental-Reduced GHG Emissions	Mid Stage (TRL 4-6)	N/A	This project aims to provide technical assistance and education to Commercial Food Service (CFS) and Residential Food Service (RFS) equipment OEMs, end users, and burner manufacturers on the benefits of energy-efficient equipment and potential decarbonized fuels. The project will also support the technical development of advanced foodservice equipment and systems in partnership with UTD members. The project will cover topics such as CFS COVID recovery, higher efficiency/lower emissions burner solutions, decarbonization options, energy efficiency and emissions, and advanced ventilation systems. The project will measure its success by the number of food equipment manufacturers assisted, meetings attended, technical presentations given, and tools and calculators updated or maintained. The project will target the large and stable commercial and residential foodservice market, which is a major source of revenue for utilities and a significant consumer of natural gas. The project will help maintain the advantage of gas over electric in the face of new decarbonization codes and standards. Since the CSF industry is predicted to be above $800 billion in 2023, with growth significantly ahead of other commercial sectors, optimizing fuel sources will be essential for overall energy efficiency.	
283	82-52	UTD Zero Emission Processes with Carb	20231018192025	Customer End-Use Applications	Commercial Applications		Commercial Applications	7/1/2023	7/31/2025	$0	$160,000	$0	$0	$0	Active	$0	UTD Members, DOE - $100,000	Improved Affordability, Environmental-Reduced GHG Emissions, Environmental-Improved Air Quality	Mid Stage (TRL 4-6)	N/A	The project aims to leverage Phase 1 results to develop advanced process layouts, scientific data, mass and energy balances, CO2 capture integration configurations, and cost estimates for synthetic air combustion (SAC) processes. The goal is to prepare for submitting proposals to governmental agencies like DOE or CEC to receive large-scale funding for next-stage, scale-up technology development and demonstration efforts. Key performance indicators for success include additional validation of projections to achieve natural gas savings of 8-15%, CO2 reduction of up to 100% when integrated with carbon capture, elimination of NOx, delivered O2 at a cost lower than the cryogenic route, applicability to a wide range of industrial furnaces and boilers, and identification of the most promising process configurations to integrate carbon capture for leading industry applications. Phase 2 builds upon the recent SAC work completed under earlier UTD-funded research, which focused on limited ambient temperature SAC combustion with oxygen and CO2, and Phase 1 of UTD project 2.21.C, which tested SAC operation with synthetic air composed of oxygen, CO2, and H2O.	