

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



**Southern California Gas Company**  
**GAS (Corp ID 904)**  
**Status of Advice Letter 5824G**  
**As of March 23, 2022**

Subject: Southern California Gas Company 2022 Research Development and Demonstration Plan  
in Compliance with Ordering Paragraph 30 of Decision 19-09-051

Division Assigned: Energy

Date Filed: 06-21-2021

Date to Calendar: 06-23-2021

Authorizing Documents: D1909051

Authorizing Documents: G-3573

<b>Disposition:</b>	<b>Signed</b>
<b>Effective Date:</b>	<b>06-21-2021</b>

Resolution Required: Yes

Resolution Number: G-3586

Commission Meeting Date: None

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



To: Energy Company Filing Advice Letter

From: Energy Division PAL Coordinator

Subject: Your Advice Letter Filing

The Energy Division of the California Public Utilities Commission has processed your recent Advice Letter (AL) filing and is returning an AL status certificate for your records.

The AL status certificate indicates:

- Advice Letter Number
- Name of Filer
- CPUC Corporate ID number of Filer
- Subject of Filing
- Date Filed
- Disposition of Filing (Accepted, Rejected, Withdrawn, etc.)
- Effective Date of Filing
- Other Miscellaneous Information (e.g., Resolution, if applicable, etc.)

The Energy Division has made no changes to your copy of the Advice Letter Filing; please review your Advice Letter Filing with the information contained in the AL status certificate, and update your Advice Letter and tariff records accordingly.

All inquiries to the California Public Utilities Commission on the status of your Advice Letter Filing will be answered by Energy Division staff based on the information contained in the Energy Division's PAL database from which the AL status certificate is generated. If you have any questions on this matter please contact the:

Energy Division's Tariff Unit by e-mail to  
**[edtariffunit@cpuc.ca.gov](mailto:edtariffunit@cpuc.ca.gov)**



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June 21, 2021

Advice No. 5824  
(U 904 G)

Public Utilities Commission of the State of California

**Subject: Southern California Gas Company 2022 Research Development and Demonstration Plan in Compliance with Ordering Paragraph 30 of Decision 19-09-051**

**Purpose**

Southern California Gas Company (SoCalGas) hereby submits this Tier 3 Advice Letter pursuant to Ordering Paragraph (OP) 30 of Decision (D.) 19-09-051 requesting approval from the California Public Utilities Commission (Commission or CPUC) to record 2022 Research Development and Demonstration (RD&D) expenses to the Research, Development, and Demonstration Expense Account (RDDEA).<sup>1</sup>

**Background**

California Public Utilities Code Section 740.1 provides for the Commission to authorize utility RD&D activities that benefit ratepayers through improved reliability and safety, environmental benefits, or operational efficiencies provided that achieving those benefits is 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.<sup>2</sup>

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<sup>1</sup> D.19-09-051 (September 26, 2019) (2019 GRC Decision), addresses the Test Year (TY) 2019 General Rate Cases (GRC) of San Diego Gas & Electric Company and SoCalGas.

<sup>2</sup> 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, 2019* (October 6, 2017), Ex. 137 SCG-21 Direct Testimony of Lisa L. Alexander at LLA-9 - LLA-20.

In the 2019 GRC Decision, the Commission found that SoCalGas' RD&D programs were both complementary and supplementary to other natural gas research and development programs<sup>3</sup> and authorized continuing the program through the TY 2019 GRC cycle at the average annual funding level requested by SoCalGas.<sup>4</sup> In addition, the 2019 GRC Decision ordered that SoCalGas:

*[ ]host an annual workshop during the second quarter of 2020 and 2021 under supervision of the Commission's Energy Division. At these workshops, SoCalGas shall present the result of the previous year's Research, Development, and Demonstration (RD&D) program and obtain input regarding its intended spending for the following calendar year. Prior to the workshop, SoCalGas shall:*

- a. Submit a report to Energy Division staff describing prior years' RD&D program including a summary of ongoing and completed projects; funds expended, funding recipients, and leveraged funding; and an explanation of the process used for selecting RD&D project areas as well as the structure of SoCalGas' RD&D portfolio;*
- b. Provide Energy Division staff with the workshop presentation materials as well as documentation of stakeholders consulted in the development of RD&D projects, both at least one week before the workshop; and*
- c. Engage relevant stakeholders to encourage their attendance at the workshop, such as the California Energy Commission, Gas Technology Institute, the U.S. Department of Energy, and other organizations engaged in gas research and development.*

*SoCalGas must also present its budget broken down by research projects, request for proposals, and funding amounts. Other specific details concerning the workshops must be coordinated with the Commission's Energy Division staff.<sup>5</sup>*

The Commission also 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 with the following information:

- (1) detail budgets broken down by research sub-program area,*
- (2) explain how the projects help improve reliability, safety, environmental benefits, or operational efficiencies, and*

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<sup>3</sup> D.19-09-051, Findings of Fact (FOF) 169, 170, and 171 at 745-746.

<sup>4</sup> *Id.* at 381.

<sup>5</sup> *Id.*, OP 30 at 783.

- (3) *discuss how SoCalGas incorporated feedback from workshop stakeholders and Commission staff.*<sup>6</sup>

In addition to the requirements outlined in the 2019 GRC Decision, the Commission provided guidance for future RD&D Research Plans in Resolution (Res.) G-3573. In developing subsequent Research Plans, SoCalGas was requested to:

- “Increase transparency in project area selection processes and criteria,<sup>7</sup> program benefit assessment processes and criteria,<sup>8</sup> stakeholder outreach efforts, and justification of consortia dues.”<sup>9</sup>
- “[I]nclude an explanation of how SoCalGas has used (or intends to use) the results of the RD&D projects” in future annual reports and proposed R&D plans, to “increase transparency and facilitate Commission and stakeholder assessment of the benefits of SoCalGas’ R&D portfolio.”<sup>10</sup>
- “[I]ncrease its focus on equity by including detail on how it will measure impacts to communities and providing additional detail on engagement with community-based organizations.”<sup>11</sup>
- “Detail how future RD&D proposals align with the State’s transportation and building decarbonization goals.”<sup>12</sup>

## **Discussion**

In accordance with the 2019 GRC Decision and Res. G-3573, SoCalGas’ RD&D staff completed the following activities to develop the 2020 Annual Report and 2022 Research Plan:

**2020 Annual Report:** On April 7, 2021, SoCalGas published and submitted its 2020 RD&D Annual Report (2020 Annual Report) to CPUC Energy Division staff for review.<sup>13</sup> The report includes a summary of ongoing and completed projects; funds expended, funding recipients, and leveraged funding; and an explanation of the process used for selecting RD&D project areas as well as the structure of SoCalGas’ RD&D portfolio. The 2020 Annual Report further

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<sup>6</sup> *Id.* at 379.

<sup>7</sup> Res. G-3573 (March 18, 2021) at 6.

<sup>8</sup> *Id.* at 6-7.

<sup>9</sup> *Id.* at 6 (requesting chart showing “dues to each consortium and their allocation to various research projects.”). See also *id.*, OP 3 at 15.

<sup>10</sup> *Id.*, OP 3 at 16.

<sup>11</sup> *Id.* at 9, and OP 3 at 16.

<sup>12</sup> *Id.*, OP 3 at 16.

<sup>13</sup> SoCalGas, Research and Development, *Transitions Research, Development, and Demonstration Program 2020 Annual Report* (2020), available at: <https://www.socalgas.com/smart-energy/research-and-development>.

describes how SoCalGas has used or intends to use the results of RD&D projects<sup>14</sup> and detail the deployment and justification of consortia dues.<sup>15</sup> In addition, the 2020 Annual Report provides details on the RD&D group's 2020 equity engagement activities.<sup>16</sup>

**2022 Research Plan Outreach:** To engage relevant stakeholders and solicit input, RD&D staff interviewed more than 50 representatives from 20 organizations, including the California Energy Commission (CEC), Gas Technology Institute (GTI), and the U.S. Department of Energy.<sup>17</sup> On April 14, 2021, RD&D staff hosted a public workshop via an online platform.<sup>18</sup> In consultation with Energy Division staff, SoCalGas also extended invitations to and encouraged participation from 170 stakeholders representing Disadvantaged Communities (DACs) within SoCalGas' service territory. Prior to the workshop, RD&D staff provided Energy Division staff with the workshop presentation materials and documentation on the stakeholders consulted in the development of the workshop presentation. Registrations for the workshop totaled 227 individuals from over 80 organizations, including the CPUC, CEC, GTI, four Department of Energy National Labs, Pipeline and Hazardous Materials Safety Administration, South Coast Air Quality Management District (SCAQMD), National Association for the Advancement of Colored People Riverside, Northridge East Neighborhood Council, Society of Hispanic Professional Engineers, and California State University, Los Angeles.

RD&D staff compiled and incorporated into the Research Plan input from stakeholder interviews, input from the workshop, and comments submitted by e-mail after the workshop. The 2022 Research Plan describes in detail the project selection process<sup>19</sup> and criteria,<sup>20</sup> as well as the Company's Equity Engagement Plan and how the RD&D program impacts on Environmental and Social Justice communities will be measured.<sup>21</sup> Input from stakeholders<sup>22</sup> led to a continued focus on hydrogen technologies to decarbonize the gas supply,

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<sup>14</sup> 2020 Annual Report at 16.

<sup>15</sup> *Id.*, Appendix at 60-67.

<sup>16</sup> *Id.* at 11.

<sup>17</sup> SoCalGas, Research and Development, *2022 SoCalGas Research Development and Demonstration Research Plan* (June 21, 2021) (2022 Research Plan), which is attached to this Advice Letter as Attachment A. The 2022 Research Plan contains detailed descriptions of stakeholder outreach efforts as well as community outreach and engagement sessions. See 2022 Research Plan at 18-20, 23.

<sup>18</sup> SoCalGas, Research and Development, *SoCalGas RD&D 2022 Research Plan – Public Workshop (online)* (April 14, 2021), available at: <https://www.socalgas.com/smart-energy/research-and-development>.

<sup>19</sup> 2022 Research Plan at 3. In addition to a narrative description of the process, a flowchart of the RD&D group's project selection process has been provided.

<sup>20</sup> *Id.* at 7-9.

<sup>21</sup> *Id.* at 24-25.

<sup>22</sup> *Id.* at Appendices A - C.

transportation sector, buildings, and end-use equipment; commitment to increase international collaboration; efforts to expand and improve knowledge transfer activities; continued research to develop and advance high-efficiency gas heat pump water heaters; and allocation of additional funds to fuel cells and combined heat and power systems.<sup>23</sup>

### **Summary of 2022 Research Plan**

The RD&D Program is divided into five program areas:

- **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—displacing conventionally sourced pipeline gas—and capturing and permanently removing or utilizing greenhouse gases (GHG).
- **Gas Operations** – The Gas Operations RD&D Program area supports pipeline transportation and storage operations through innovations that enhance pipeline and employee safety, maintain system reliability, increase operational efficiency, and minimize GHG and operational impacts to the environment. The program also supports 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.
- **Clean Transportation** – The Clean Transportation RD&D 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.
- **Clean Generation** – The Clean Generation RD&D 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.
- **Customer End-Use Applications** – The Customer End-Use Applications RD&D Program area focuses on developing, demonstrating, and commercializing technologies that cost-effectively improve the efficiency

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<sup>23</sup> *Id.*, at Section 5.3, “Response to Stakeholder Input,” for more detail of how stakeholder input was incorporated into the Research Plan.

and reduce the environmental impacts of gas equipment used in residential, commercial, and industrial settings.

Each program area is further divided into multiple sub-program areas. The 2022 Research Plan, provided as Attachment A to this Advice Letter, describes how projects in each sub-program area help improve reliability, safety, environmental benefits, or operational efficiencies.<sup>24</sup> A description of how RD&D proposals “align with the State's transportation and building decarbonization goals”<sup>25</sup> is identified generally in the key policy drivers for the RD&D program,<sup>26</sup> and specifically, policy drivers and benefits are listed for each sub-program in Attachment A.<sup>27</sup>

RD&D Program staff consider a variety of factors in determining how to allocate funding, including regulatory and policy drivers, input from knowledgeable stakeholders, input from CPUC Energy Division staff, and other interested parties at an annual workshop.

The total authorized funding for the RD&D program was established by escalating the 2019 funding level authorized by the TY2019 GRC decision to 2022 dollars. For 2022, the escalated, authorized funding amount is \$16.49 million. This funding may be adjusted in 2022 to incorporate overspend or underspend in 2021.<sup>28</sup>

To allocate the 2022 budget, first, the Program Administration costs were forecasted at 10% of total funding. The Program Administration costs include costs associated with: 1) management and administrative labor, 2) compliance and reporting 3) program planning and workshops; 4) education and outreach; and 5) equity engagement. Next, each subprogram identified the level of funding that will be spent in 2022, taking into consideration projects that are currently under contract, projects that are in the contracting process, projects that are under development for 2022, and stakeholder input. Then, for each subprogram, key research areas, with examples of potential interest that could be funded if the appropriate projects are developed, are described. Funds may also be directed to other research areas that arise during the plan year. Table A below provides a summary of the 2022 RD&D budget by research sub-program area.

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<sup>24</sup> For an explanation of how projects in each sub-program improve reliability, safety, environmental benefits or operational efficiencies, see the section for each sub-program titled “Sub-program Benefits” contained in the 2022 Research Plan (e.g., 7.2.2 for Renewable Gas Production, 7.3.2 for Carbon Capture, Utilization, and Sequestration, etc.).

<sup>25</sup> Res. G-3573, OP 3 at 16.

<sup>26</sup> See 2022 Research Plan at 10-11.

<sup>27</sup> Details are provided in the section for each sub-program titled “Sub-program Benefits” (e.g., 7.2.2 for Renewable Gas Production, 7.3.2 for Carbon Capture, Utilization, and Sequestration, etc.) and the section for each sub-program titled “Policy Considerations” (e.g., 7.2.4 for Renewable Gas Production, 7.3.4 for Carbon Capture, Utilization, and Sequestration, etc.).

<sup>28</sup> See Res. G-3573 at 13.



**Table A: 2022 RD&D Program Budget**

Programs	2022 Program Funding	Subprograms	2022 Subprogram Funding
Low Carbon Resources	\$5,492,502	Renewable Gas Production	\$3,295,501
		Carbon Capture, Utilization, & Sequestration	\$2,197,001
Gas Operations	\$3,562,704	Environmental & Safety	\$712,541
		Operations Technology	\$534,406
		System Design & Materials	\$1,425,081
		System Inspection & Monitoring	\$890,676
		Off-Road	\$623,473
Clean Transportation	\$2,078,244	On-Road	\$623,473
		Refueling Stations	\$415,649
		Onboard Storage	\$415,649
Clean Generation	\$1,632,906	Distributed Generation	\$1,224,680
		Integration & Controls	\$408,226
Customer End-Use Applications	\$2,078,244	Commercial Food Service	\$145,476
		Residential Appliances	\$665,038
		Commercial Applications	\$311,737
		Industrial Process Heat	\$831,298
		Advanced Innovation	\$124,695
Program Administration	\$1,649,400		
<b>Total</b>	<b>\$16,494,000</b>		

**Funding for Multi-year Projects Contracted Prior to 2022**

In the 2019 GRC Decision, the Commission permitted the RD&D Program to conclude multi-year projects initiated prior to the 2021 Plan:

*[ ]costs related to multi-year project and single-year projects under the current RD&D program will continue to be funded consistent with the TY2016 protocols until the planned completion of those projects.<sup>29</sup>*

Notwithstanding D.19-09-051, in Res. G-3573, the Commission did not authorize 2021 costs to be recorded in designated portions of the Clean Transportation sub-program. Two projects awarded funding in Plan years prior to 2021 fell within this prohibition. These two projects are described more fully below, with a request to continue funding until the contractual commitment concludes pursuant to their terms.

Why is this important?

It protects ratepayer funds: Many projects take multiple years to complete. Structuring the contracts to extend over the life of the project allows for a milestone-based payment structure. This protects ratepayer funds from going to a project that fails or is canceled before completion.

<sup>29</sup> D.19-09-051 at 379.

Furthermore, if projects are canceled before completion, ratepayers lose the benefits the research would have provided and have invested in research without receiving beneficial results.

The sanctity of contracts is important: RD&D funding recipients need to know that the Company's contracts (and funding commitment) will be honored so the recipients can be confident in spending funds to execute their research. Without that certainty, SoCalGas will not be able to attract the high-quality researchers that have made the RD&D program so successful to date.

It is consistent with the CEC's Research & Development funding structure: The CEC "encumbers" funds by contract during a given plan year. The total funding is not immediately released but is instead allocated to a project over its term. That way, project funding remains milestone-based, and the authorization for the research is provided by the Research Plan for the year the project originated.

For each of these reasons, SoCalGas requests authority to complete the funding of the following two projects contracted prior to the adoption of Res. G-3573:

**1. SCAQMD Ford 7.3L Near-Zero Emission Engine Development**<sup>30</sup>

For the 2021 Research Plan, this project was classified under the Clean Transportation RD&D Program, On-Road Sub-Program, Research Area 1: Near-Zero Emission CNG Engine Development.<sup>31</sup>

This project seeks to develop and commercialize the Ford 7.3L compressed natural gas (CNG) near-zero emissions (NZE) engine for medium-duty trucks. Two developers - Landi Renzo and Agility Fuel Solutions, LLC - will develop a NZE variant of the Ford 7.3L CNG engine for medium-duty trucks. With the exception of the Cummins Westport, Inc. ISB 6.7 engine, the medium-duty truck market does not have a commercially available NZE engine alternative. The Ford 7.3L engine will be calibrated and certified to 0.02 g/bhp-hr NOx. This project could lead to an increase NZE engine options for medium-duty fleets, which could increase market competition and lead to reduced engine prices. Landi Renzo and Agility Fuel Solutions, LLC, are confident that the successfully developed 7.3L CNG NZE engine will be widely adopted into Ford medium-duty truck platforms.

The project was contracted with SCAQMD in January 2020. The total funding commitment from SoCalGas RD&D is \$454,325, of which \$300,000 was provided in 2020, and \$154,325 remains to be funded to complete the project. The project is supported by co-funding from SCAQMD, Ford, US Gain, Landi Renzo, and Agility Fuel Systems, LLC.

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<sup>30</sup> 2020 Annual Report, Appendix at 171.

<sup>31</sup> See SoCalGas Advice No. 5652 submitted on June 25, 2020, Attachment A, 2021 Research Development and Demonstration Program Research Plan at 42.

## **2. Southwest Research Institute (SWRI) Development of Pent-Roof Natural Gas Engine in an Optimized Hybrid Vehicle System**<sup>32</sup>

For the 2021 Research Plan, this project was classified under the Clean Transportation RD&D Program, On-Road Sub-Program, Research Area 1: Near-Zero Emission CNG Engine Development.<sup>33</sup>

This project seeks to develop a pent-roof cylinder head engine for a natural gas engine and integrate it into a medium-duty truck chassis. A pent-roof design is an optimum approach for developing a high-efficiency natural gas engine and will provide substantial gains over engine designs that retain the flat head of a diesel engine. The pent-roof design will also enable the use of high levels of exhaust gas recirculation dilution to yield a high-efficiency engine that can also easily meet future NOx regulations. A hybrid drivetrain system will be integrated into the truck as well. This integration will further the vehicle-level efficiency gains and demonstrate a highly optimized low GHG emission medium-duty truck.

The project was awarded \$2,525,000 from the U.S. Department of Energy's National Renewable Energy Laboratory in 2019, in part, based on co-funding committed by SoCalGas RD&D. The project was contracted with SWRI in January 2021. The total funding commitment from SoCalGas RD&D of \$200,000 remains to be funded to complete the project. The project is supported with co-funding from SCAQMD (\$525,000), Isuzu (\$2,139,000), and Southwest Research Institute (\$660,100).

In addition to the factors described above, which warrant the continuation of multi-year projects that were initiated prior to the 2021 Plan year request, stakeholders that participated in the RD&D Workshop held on April 14, 2021 expressed support for continuing development of NZE CNG engines based on the air quality improvements and GHG reduction opportunities this type of technology can provide. For example, Natural Gas Vehicles for America (NGVAmerica) commented that "near-zero engines using renewable natural gas can deliver carbon neutral and even carbon negative emission results and virtually eliminate criteria pollutants provided much needed emission reductions for California,"<sup>34</sup> as did GTI, stating "The benefits of near-zero engines and renewable natural gas are too great to ignore as they can provide near-term solutions, at the necessary scale, to help solve the enormous environmental concerns seen throughout California today."<sup>35</sup>

Consistent with the intent of the 2019 GRC Decision, SoCalGas requests that funding for multi-year projects that were initiated prior to the 2021 RD&D Plan be permitted to conclude according to the terms of their contracts.

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<sup>32</sup> 2020 Annual Report, Appendix at 172.

<sup>33</sup> See SoCalGas Advice No. 5652 submitted June 25, 2020, Attachment A, *2021 Research Development and Demonstration Program Research Plan* at 42.

<sup>34</sup> The full content of the comments submitted by NGVAmerica are contained in 2022 Research Plan, Appendix C at 88-90.

<sup>35</sup> *Id.* at 98-99.

**Protests and Responses**

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 made in writing and must be received within 20 days of the date of this Advice Letter, which is July 11, 2021. The address for mailing or delivering a protest to the Commission is:

CPUC Energy Division  
Attention: Tariff Unit  
505 Van Ness Avenue  
San Francisco, CA 94102

A copy of the protest should also be sent via e-mail to the attention of the CPUC's Energy Division Tariff Unit ([EDTariffUnit@cpuc.ca.gov](mailto:EDTariffUnit@cpuc.ca.gov)). Due to the COVID-19 pandemic and the shelter at home orders, SoCalGas is currently unable to receive protests or comments to this Advice Letter via U.S. mail or fax. Please submit protests or comments to this Advice Letter via e-mail to the addresses shown below on the same date it is mailed or e-mailed to the Commission.

Attn: Ray B. Ortiz  
Tariff Manager - GT14D6  
555 West Fifth Street  
Los Angeles, CA 90013-1011  
Facsimile No.: (213) 244-4957  
E-mail: [ROrtiz@socalgas.com](mailto:ROrtiz@socalgas.com)  
E-mail: [Tariffs@socalgas.com](mailto:Tariffs@socalgas.com)

**Effective Date**

OP 30 of D.19-09-051 directs SoCalGas to submit this Advice Letter as Tier 3 pursuant to General Order (GO) 96-B and, as such, requires a Resolution to be issued by the Commission. Accordingly, SoCalGas respectfully requests that it be approved by the Commission by December 1, 2021 to support the planning and initiation of 2022 RD&D program activities.

**Notice**

A copy of this Advice Letter is being sent to SoCalGas' GO 96-B service list and the Commission's service lists in A.17-10-007 and A.17-10-008. Address change requests to the GO 96-B service list should be directed via e-mail to [Tariffs@socalgas.com](mailto:Tariffs@socalgas.com) or call 213-244-2837. For changes to all other service lists, please contact the CPUC's Process Office at 415-703-2021 or via e-mail at [Process\\_Office@cpuc.ca.gov](mailto:Process_Office@cpuc.ca.gov).

*/s/ Joseph Mock*  
Joseph Mock  
Director – Regulatory Affairs

Attachment



# 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<sup>1</sup>:

Pending advice letters that revise the same tariff sheets:

<sup>1</sup>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](mailto:EDTariffUnit@cpuc.ca.gov)

Name:  
Title:  
Utility Name:  
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State: Zip:  
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Email:

Name:  
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Utility Name:  
Address:  
City:  
State: Zip:  
Telephone (xxx) xxx-xxxx:  
Facsimile (xxx) xxx-xxxx:  
Email:

**ATTACHMENT A**

**Advice No. 5824**

**2022 SoCalGas Research Development  
and Demonstration Research Plan**



# 2022 SoCalGas Research, Development, and Demonstration Program

RESEARCH PLAN



JUNE 21, 2021

“With reliance on renewable energy sources growing every year, the decarbonization of the energy sector is well underway. SoCalGas is playing a pivotal role in this transformation by developing clean energy innovations and energy efficiency technologies as well as advancing hydrogen for use in both transportation and energy storage.”

—**Maryam Brown**  
President  
SoCalGas

## TABLE OF CONTENTS

<b>1</b>	<b>OVERVIEW .....</b>	<b>1</b>
1.1	ASPIRE 2045 .....	1
1.2	RD&D PROGRAM GOALS AND STRUCTURE .....	3
1.2.1	<i>Program Goals</i> .....	3
1.2.2	<i>Program Structure</i> .....	3
1.3	PROJECT SELECTION PROCESS AND EVALUATION CRITERIA .....	3
1.4	MEASURING SUCCESS .....	9
<b>2</b>	<b>RD&amp;D PROGRAM RESEARCH PLAN DEVELOPMENT .....</b>	<b>10</b>
2.1	REGULATORY AND POLICY DRIVERS .....	10
2.2	RD&D LANDSCAPE .....	11
2.2.1	<i>Public Agencies</i> .....	11
2.2.2	<i>Universities</i> .....	15
2.2.3	<i>National Laboratories</i> .....	15
2.2.4	<i>Businesses</i> .....	15
2.2.5	<i>Research Consortia</i> .....	15
2.2.6	<i>SoCalGas RD&amp;D Program</i> .....	16
<b>3</b>	<b>STAKEHOLDER INPUT .....</b>	<b>18</b>
3.1	STAKEHOLDER OUTREACH .....	18
3.2	ANNUAL STAKEHOLDER WORKSHOP .....	18
3.3	INCORPORATION OF STAKEHOLDER INPUT .....	19
<b>4</b>	<b>EQUITY.....</b>	<b>21</b>
4.1	ENVIRONMENTAL AND SOCIAL JUSTICE COMMUNITIES AND CLIMATE CHANGE .....	21
4.2	DIVERSITY, EQUITY, AND INCLUSION AT SOCALGAS .....	21
4.3	EQUITY IN THE RD&D PROGRAM.....	22
4.4	2021 EQUITY PROGRESS REPORT .....	22
4.5	2022 EQUITY ENGAGEMENT PLAN.....	24
<b>5</b>	<b>NEW IN 2022.....</b>	<b>26</b>
5.1	NEW SUBPROGRAM CATEGORIES .....	26
5.2	ASPIRE 2045 .....	26
5.3	RESPONSE TO STAKEHOLDER INPUT .....	27
<b>6</b>	<b>PROPOSED 2022 FUNDING ALLOCATIONS.....</b>	<b>29</b>
<b>7</b>	<b>LOW CARBON RESOURCES .....</b>	<b>31</b>
7.1	PROPOSED 2022 LOW CARBON RESOURCES FUNDING ALLOCATION .....	31
7.2	RENEWABLE GAS PRODUCTION .....	32
7.2.1	<i>Subprogram Overview</i> .....	32
7.2.2	<i>Subprogram Benefits</i> .....	32
7.2.3	<i>2022 Key Research Areas</i> .....	33
7.2.4	<i>Policy Considerations</i> .....	34
7.2.5	<i>Equity Considerations</i> .....	34
7.3	CARBON CAPTURE, UTILIZATION, AND SEQUESTRATION.....	35
7.3.1	<i>Subprogram Overview</i> .....	35
7.3.2	<i>Subprogram Benefits</i> .....	35
7.3.3	<i>2022 Key Research Areas</i> .....	35
7.3.4	<i>Policy Considerations</i> .....	36
7.3.5	<i>Equity Considerations</i> .....	37

<b>8</b>	<b>GAS OPERATIONS</b>	<b>38</b>
8.1	PROGRAM BENEFITS	38
8.1.1	Equity Considerations	39
8.2	PROPOSED 2022 GAS OPERATIONS FUNDING ALLOCATION	39
8.3	ENVIRONMENTAL & SAFETY	39
8.3.1	Subprogram Overview	39
8.3.2	2022 Key Research Areas	40
8.3.3	Policy Considerations	40
8.4	OPERATIONS TECHNOLOGY	40
8.4.1	Subprogram Overview	40
8.4.2	2022 Key Research Areas	41
8.4.3	Policy Considerations	41
8.5	SYSTEM DESIGN & MATERIALS	41
8.5.1	Subprogram Overview	41
8.5.2	2022 Key Research Areas	42
8.5.3	Policy Considerations	43
8.6	SYSTEM INSPECTION & MONITORING	43
8.6.1	Subprogram Overview	43
8.6.2	2022 Key Research Areas	43
8.6.3	Policy Considerations	44
<b>9</b>	<b>CLEAN TRANSPORTATION</b>	<b>45</b>
9.1	PROPOSED 2022 CLEAN TRANSPORTATION FUNDING ALLOCATION	45
9.2	OFF-ROAD	45
9.2.1	Subprogram Overview	45
9.2.2	Subprogram Benefits	46
9.2.3	2022 Research Areas	46
9.2.4	Policy Considerations	47
9.2.5	Equity Considerations	47
9.3	ON-ROAD	47
9.3.1	Subprogram Overview	47
9.3.2	Subprogram Benefits	47
9.3.3	2022 Key Research Areas	48
9.3.4	Policy Considerations	48
9.3.5	Equity Considerations	49
9.4	REFUELING STATIONS	49
9.4.1	Subprogram Overview	49
9.4.2	Subprogram Benefits	49
9.4.3	2022 Key Research Areas	49
9.4.4	Policy Considerations	50
9.4.5	Equity Considerations	50
9.5	ONBOARD STORAGE	50
9.5.1	Subprogram Overview	50
9.5.2	Subprogram Benefits	50
9.5.3	2022 Key Research Areas	51
9.5.4	Policy Considerations	51
9.5.5	Equity Considerations	51
<b>10</b>	<b>CLEAN GENERATION</b>	<b>52</b>
10.1	PROPOSED 2022 CLEAN GENERATION FUNDING ALLOCATION	52
10.2	DISTRIBUTED GENERATION	52
10.2.1	Subprogram Overview	52

10.2.2	<i>Subprogram Benefits</i>	52
10.2.3	<i>2022 Key Research Areas</i>	53
10.2.4	<i>Policy Considerations</i>	53
10.2.5	<i>Equity Considerations</i>	54
10.3	INTEGRATION & CONTROLS	54
10.3.1	<i>Subprogram Overview</i>	54
10.3.2	<i>Subprogram Benefits</i>	54
10.3.3	<i>2022 Key Research Areas</i>	54
10.3.4	<i>Policy Considerations</i>	55
10.3.5	<i>Equity Considerations</i>	55
<b>11</b>	<b>CUSTOMER END-USE APPLICATIONS</b>	<b>56</b>
11.1	PROPOSED 2022 CUSTOMER END-USE APPLICATIONS FUNDING ALLOCATION	56
11.2	COMMERCIAL FOOD SERVICE	56
11.2.1	<i>Subprogram Overview</i>	56
11.2.2	<i>Subprogram Benefits</i>	56
11.2.3	<i>2022 Key Research Areas</i>	57
11.2.4	<i>Policy Considerations</i>	57
11.2.5	<i>Equity Considerations</i>	57
11.3	RESIDENTIAL APPLIANCES	58
11.3.1	<i>Subprogram Overview</i>	58
11.3.2	<i>Subprogram Benefits</i>	58
11.3.3	<i>2022 Key Research Areas</i>	58
11.3.4	<i>Policy Considerations</i>	58
11.3.5	<i>Equity Considerations</i>	59
11.4	COMMERCIAL APPLICATIONS	59
11.4.1	<i>Subprogram Overview</i>	59
11.4.2	<i>Subprogram Benefits</i>	59
11.4.3	<i>2022 Key Research Areas</i>	59
11.4.4	<i>Policy Considerations</i>	59
11.4.5	<i>Equity Considerations</i>	60
11.5	INDUSTRIAL PROCESS EQUIPMENT	60
11.5.1	<i>Subprogram Overview</i>	60
11.5.2	<i>2022 Key Research Areas</i>	60
11.5.3	<i>Policy Considerations</i>	61
11.5.4	<i>Equity Considerations</i>	61
11.6	ADVANCED INNOVATION	61
11.6.1	<i>Subprogram Overview</i>	61
11.6.2	<i>Subprogram Benefits</i>	61
11.6.3	<i>2022 Key Research Areas</i>	62
11.6.4	<i>Policy Considerations</i>	62
11.6.5	<i>Equity Considerations</i>	63
	<b>APPENDIX A: STAKEHOLDER INPUT</b>	<b>64</b>
	<b>APPENDIX B: PUBLIC WORKSHOP QUESTIONS &amp; COMMENTS</b>	<b>74</b>
	<b>APPENDIX C: POST-WORKSHOP STAKEHOLDER INPUT</b>	<b>88</b>

## ACRONYMS

<b>Acronym</b>	<b>Description</b>
AB	Assembly Bill
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
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
CO <sub>2</sub>	Carbon Dioxide
CPUC	California Public Utilities Commission
CSP	Concentrated Solar Power
CSU	California State University
CTP	Clean Transportation Program
DBE	Diverse Business Enterprise
DG	Distributed Generation
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EERE	Energy Efficiency and Renewable Energy
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
GTI	Gas Technology Institute
HFCV	Hydrogen Fuel Cell Vehicle
IoT	Internet of Things
LCFS	Low Carbon Fuel Standard
MHD	Medium- and Heavy-Duty
NAACP	National Association for the Advancement of Colored People
NETL	National Energy Technology Laboratory

NGA	Northeast Gas Association
NGRP	Natural Gas Research Program
NREL	National Renewable Energy Laboratory
OIR	Order Instituting Rulemaking
OTD	Operations Technology Development
PE	Polyethylene
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
UC	University of California
UTD	Utilization Technology Development
ZEV	Zero-Emission Vehicle

# 1 Overview

## 1.1 ASPIRE 2045

The mission of the Southern California Gas Company—SoCalGas—is to build the cleanest, safest, and most innovative energy company in America. In support of that mission, the company recently announced ASPIRE 2045,<sup>1</sup> a sustainability strategy that includes a bold commitment to achieve net-zero greenhouse gas (GHG) emissions in our operations and delivery of energy by 2045. Building on efforts to date, SoCalGas has mapped out transitional goals on the path towards net-zero GHG emissions.

**Table 1:** SoCalGas has ambitious environmental goals and will add new ones as 2045 approaches.

2025
<ul style="list-style-type: none"><li>• Achieve net-zero energy for 100% of SoCalGas’ newly constructed buildings and major renovations of buildings over 10,000 square feet.<sup>2</sup></li><li>• Replace 50% of SoCalGas’ over-the-road fleet with electric, hybrid, renewable gas, and fuel cell electric vehicles (EVs).<sup>3</sup></li><li>• Complete five hydrogen pilot projects.</li><li>• Establish statewide hydrogen blending standards.</li><li>• Exceed the state requirements to demonstrate a 20% reduction in fugitive methane emissions by 2025.<sup>4</sup></li><li>• Reduce methane emissions intensity of our distribution system to less than or equal to 0.22% of total gas delivered, contributing to the collective goal of the ONE Future Coalition.<sup>5</sup></li><li>• Deliver 5% renewable natural gas (by 2022).<sup>6</sup></li><li>• Increase procurement of responsibly sourced gas.<sup>7</sup></li></ul>
2030
<ul style="list-style-type: none"><li>• Eliminate 100% of vented gas during planned transmission pipeline work (excluding emergency repairs).</li><li>• Achieve net-zero energy for 50% of all existing SoCalGas buildings.<sup>8</sup></li><li>• Develop hydrogen infrastructure solutions for the 2028 Olympics.</li><li>• Exceed California’s goal to reduce fugitive methane emissions by 40% by 2030.<sup>9</sup></li><li>• Deliver 20% renewable natural gas.<sup>10</sup></li><li>• Establish a hydrogen industrial cluster with industry partners.</li></ul>

<sup>1</sup> See ASPIRE 2045, Sustainability and Climate Commitment to Net Zero, available at [https://www.socalgas.com/sites/default/files/2021-03/SoCalGas\\_Climate\\_Commitment.pdf](https://www.socalgas.com/sites/default/files/2021-03/SoCalGas_Climate_Commitment.pdf).

<sup>2</sup> Excludes compressor, transmission, and meters and regulations facilities.

<sup>3</sup> Dependent on functional application and availability of vehicle products.

<sup>4</sup> See Senate Bill (SB) 1371, available at: [https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill\\_id=201320140SB1371](https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1371).

<sup>5</sup> The ONE Future Coalition is a group of 38 natural gas companies working together to voluntarily reduce methane emissions across the natural gas value chain to 1% (or less) by 2025, available at <https://onefuture.us/>.

<sup>6</sup> Specifically, we aim to provide 5% renewable natural gas to our “core service” as defined in SoCalGas’ Tariff Rule No. 23, by 2022.

<sup>7</sup> “Responsibly sourced gas” is natural gas procured from suppliers that proactively manage methane emissions across their entire gas supply chain.

<sup>8</sup> Excludes compressor, transmission, and meters and regulations facilities.

<sup>9</sup> See SB 1371, available at: [https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill\\_id=201320140SB1371](https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB1371).

<sup>10</sup> Specifically, we aim to provide 20% renewable natural gas to our “core service” as defined in SoCalGas’ Tariff Rule No. 23, by 2030.



## 2035

- Operate a 100% zero-emission, over-the-road fleet.<sup>11</sup>
- Achieve net-zero energy for 100% of SoCalGas buildings.<sup>12</sup>

Innovation and the rapid development of new technologies will be vital to the company’s success in achieving the goals discussed above. The SoCalGas Research, Development, and Demonstration (RD&D) Program plays a key role in this effort by developing and demonstrating 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 2:** 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			
SCIENCE	SYNERGY	EQUITY	
Our experts in science, engineering, energy systems, and environmental policy seek answers to some of today’s most pressing energy questions.	We work with the world’s finest researchers in universities, national labs, and industry to develop transformational technologies that support decarbonization, energy security, and economic development.	We champion technologies that support affordable access to clean, safe, and reliable energy for all Californians.	

The RD&D Program is staffed with subject matter experts (SME) in science, engineering, industrial process technology, and environmental policy. They regularly collaborate with the world’s top institutions—including the U.S. Department of Energy (DOE), the National Renewable Energy Laboratory (NREL), the California Energy Commission (CEC), Gas Technology Institute (GTI), the California Institute of Technology (Caltech), the University of California (UC), and Stanford University—to ensure that the work SoCalGas supports supplements and complements its efforts and addresses the most pressing technological gaps in the field.

Every year, program 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 2020, the RD&D Program provided technical assistance, outreach, strategic guidance, and almost \$15 million in funding to 386 projects throughout California and around the nation. In 2022, RD&D Program staff anticipate increasing that total to \$16,494,000.

<sup>11</sup> Dependent on functional application and availability of vehicle products.

<sup>12</sup> Excludes compressor, transmission, and meters and regulations facilities.

## 1.2 RD&D Program Goals and Structure

### 1.2.1 Program Goals

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. These goals are in alignment with California’s transportation and building decarbonization goals and SoCalGas’ greater goals to achieve net-zero GHG emissions in its operations and delivery of energy by 2045.

### 1.2.2 Program Structure

In 2022, the RD&D Program intends to allocate funding across five research program areas—Low Carbon Resources, Gas Operations, Clean Transportation, Clean Generation, and Customer End-Use Applications—and multiple associated subprograms.

**Table 3:** The RD&D Program is divided into five program areas and 17 subprograms.

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

## 1.3 Project Selection Process and Project Evaluation Criteria

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.

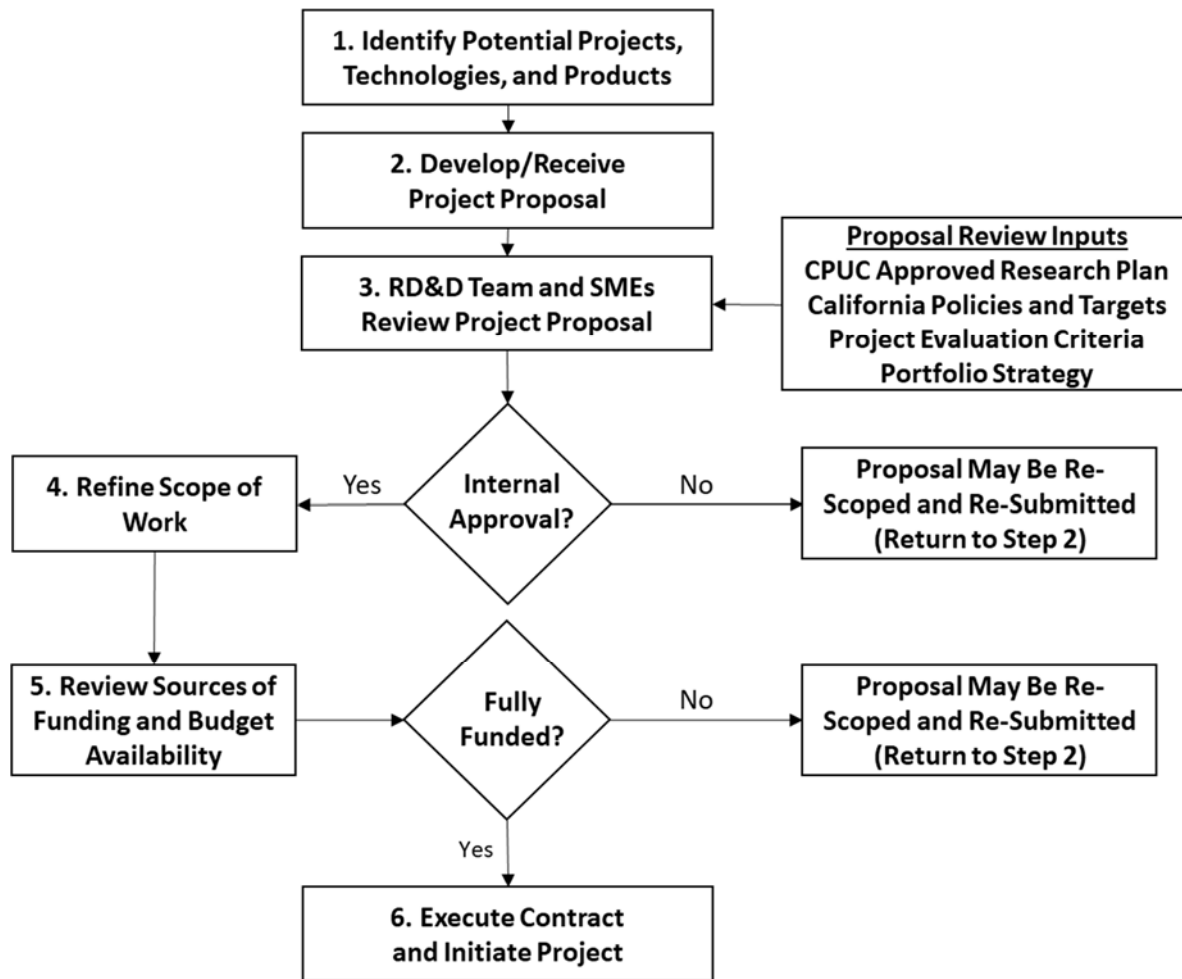
RD&D Program area staff explore a variety of avenues to identify and conceive potential projects, including:

**Table 4:** RD&D Program area staff explore many avenues to identify and conceive potential projects.

<p><b>Addressing Internal Operations Needs</b></p>	<p>RD&amp;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&amp;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.</p>
<p><b>Addressing Customer Needs</b></p>	<p>SoCalGas Account Executives work closely with commercial and industrial customers. The Customer Strategy &amp; Engagement group interacts with residential customers through programs such as the Customer Insight Panel. These teams often bring customer challenges to RD&amp;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.</p>
<p><b>Literature Surveys, Conferences, and Workshops</b></p>	<p>RD&amp;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.</p>
<p><b>Research Consortia</b></p>	<p>RD&amp;D Program staff leverage the national and international experience of other utilities through participation in industry research consortia, such as Utilization Technology Development (UTD) and Pipeline Research Council International (PRCI). Close relationships with these organizations facilitate the generation of project ideas, enable SoCalGas to vet potential projects with real-world end-users, and provide access to significant amounts of co-funding.</p>
<p><b>External Funding Opportunities</b></p>	<p>When public agencies, such as the CEC or the DOE, release a funding opportunity, RD&amp;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&amp;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.</p>

<b>Proposals from Researchers</b>	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.
<b>Technology Roadmap Development</b>	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.
<b>Public Workshops and Outreach</b>	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 discussions 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.
<b>Policy Drivers</b>	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 programs have distinct research interests, goals, and industry relationships, all follow a similar high-level approach to project identification and selection. Figure 1 shows the process RD&D staff use to review, approve, and fund proposed research projects.



**Figure 1:** RD&D internal project proposal review process.

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 inputs, including the current CPUC approved RD&D Research Plan, California policies and targets, project evaluation criteria, and the overall portfolio strategy; 4) refine scopes of work for approved projects, if necessary; 5) review funding sources and ensure budget availability following SoCalGas accounting policies; and 6) execute the project contract and initiate project research. Projects that do not receive Internal approval or sufficient funding may be directed to adjust the project scope and re-start that approval process at Step 2.

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 5). The criteria were also influenced by stakeholder input (e.g., included equity in response to feedback from multiple stakeholders), 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 the 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 5:** RD&D Program staff relied primarily on CPU Code 740.1 in developing project evaluation criteria.

<b>Criterion</b>	<b>Relevant Section of CPU Code 740.1</b>	<b>Relevant Language</b>
<b>Customer Benefit</b>	740.1a	“Projects should offer a reasonable probability of providing benefits to ratepayers.”
	740.1e	<p>“Each project should also support one or more of the following objectives:</p> <p>(1) Environmental improvement.</p> <p>(2) Public and employee safety.</p> <p>(3) Conservation by efficient resource use or by reducing or shifting system load.</p> <p>(4) Development of new resources and processes, particularly renewable resources and processes which further supply technologies.</p> <p>(5) Improve operating efficiency and reliability or otherwise reduce operating costs.”</p>
<b>Lead Investigator/Team</b>		
<b>Technical Feasibility</b>	740.1b	“Expenditures on projects which have a low probability for success should be minimized.”
<b>Commercialization Potential</b>		
<b>Alignment with California Policy</b>	740.1c	<p>“Projects should be consistent with the corporation’s resource plan.”</p> <p>SoCalGas also considers guidance from stakeholders and regulators to ensure that that projects support California’s environmental goals.</p>
<b>Co-funding Collaborators</b>	740.1d	“Projects should not unnecessarily duplicate research currently, previously, or imminently undertaken by other electrical or gas corporations or research organizations.”
<b>Equity</b>	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 2022 project evaluation criteria are as follows:

Criterion	Description/Justification
<b>Customer Benefit</b>	<p>RD&amp;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&amp;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, internal (<i>i.e.</i>, RD&amp;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&amp;D) organizations?</p>
<b>Alignment with California Policy</b>	<p>The RD&amp;D team also has a responsibility to allocate funding in ways that support company, state, and federal objectives. To assess this criterion, RD&amp;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 on the development roadmap? Does the research address an internal operational need?</p>
<b>Lead Investigator/Team</b>	<p>Successful R&amp;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&amp;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 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?</p>
<b>Technical Feasibility</b>	<p>Although the RD&amp;D Program team funds early-stage RD&amp;D Program projects, it has a responsibility to ratepayers to fund projects with a high likelihood of success. To assess this criterion, RD&amp;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 techno-economic fundamentals? Does documentation of proof-of-concept work exist?</p>
<b>Co-funding Collaborators</b>	<p>One of the key objectives of the RD&amp;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 2020, every dollar of RD&amp;D Program funds expended was matched by an average of \$6.90 in funding from other sources. To assess this criterion, RD&amp;D Program staff ask questions such as: Are other R&amp;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&amp;D Program funding? Are other stakeholders supportive of the research? Is there consortium involvement to minimize the risk of duplicating work?</p>

Criterion	Description/Justification
<b>Commercialization Potential</b>	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 compared 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 with proven track records with similar products or technologies?
<b>Equity Considerations</b>	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?

## 1.4 Measuring Success

To assess the degree to which a given project and the program are successful, RD&D Program staff track and analyze a variety of metrics, including:

**Table 6:** RD&D Program staff use a variety of metrics to evaluate the success of funded projects and the RD&D Program.

Project Level Metrics	Program Level Metrics
	Number of Projects Initiated
Produces a Published Report	Number Projects Completed
Results in Patent Application Filing(s)	Total Number of Projects
Results in Regulatory Revision or Adoption	Number of Products, Services, or Technologies Commercialized/Deployed
Results in a Method Adopted into Practice	Number of Reports Published
Commercialized Products and/or Services	Number of Patents and Patent Applications Filed
Informs or Leads to Future Research	Number of Projects by Program Benefit <sup>13</sup>

<sup>13</sup> The six benefits of RD&D projects are: Reliability; Safety; Operational Efficiency; Improved Affordability; Environmental—Reduced GHG Emissions; and Environmental—Improved Air Quality.



## 2 RD&D Program Research Plan Development

RD&D Program 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 ESJ communities. The process is designed to optimize subprogram level funding allocations, provide an opportunity for stakeholder input, and maximize progress toward overarching program goals and objectives.

### 2.1 Regulatory and Policy Drivers

**Table 7:** Key state and federal policies and regulations impacting the RD&D Program.

Category	Regulations and Policy Drivers
GHG Emissions	<p><b>SB 32:</b> Reduce carbon dioxide (CO<sub>2</sub>) emissions 40% below 1990 levels by 2030</p> <p><b>SB 100:</b> Zero-carbon electricity by 2045</p> <p><b>EO B-55-18:</b> Carbon-neutral California economy by 2045</p> <p><b>AB 3232:</b> Reduce GHG emissions from residential and commercial buildings by 40 below 1990 levels by 2030</p> <p><b>SB 1383:</b> Reduce methane emissions from decomposition of organic wastes</p>
Pipeline Safety	<p><b>CPUC General Order 112F:</b> Rules governing design, testing, operation, and maintenance of gas transmission and distribution (T&amp;D) systems</p> <p><b>U.S. Department of Transportation (DOT) 49 Code of Federal Regulations (CFR) Part 192:</b> Federal pipeline safety regulations</p> <p><b>AB 1900:</b> Biomethane quality standards</p> <p><b>Order Institute Rulemaking (OIR) R.13-02-008, Phase 4:</b> Addresses injection of renewable hydrogen into gas pipelines</p>
Air Quality	<p><b>Clean Air Act:</b> Air quality standards for nitrogen oxides (NO<sub>x</sub>) and particulate matter (PM)</p> <p><b>AB 617:</b> Nonvehicular air pollution: criteria air pollutants and toxic air contaminants</p> <p><b>AB 2588:</b> Established a statewide program for the inventory of air toxics emissions from individual facilities as well as requirements for risk assessment and public notification of potential health risks.</p> <p><b>40 CFR Part 63 National Emission Standards for Hazardous Air Pollutants:</b> Stationary source standards for hazardous air pollutants.</p>
Clean Transportation	<p><b>ARB Implementation Plan:</b> Low-NO<sub>x</sub> standard for trucks</p> <p><b>AB 8:</b> Development of 100 hydrogen fueling stations in California</p> <p><b>EO B32-15:</b> Sustainable freight action plan</p> <p><b>EO B48-18:</b> 200 hydrogen refueling stations by 2025</p> <p><b>EO N-79-20:</b> 100% of MHDs be zero emission by 2045 for all operations where feasible</p> <p><b>Low Carbon Fuel Standard (LCFS):</b> Reduce carbon intensity of fuels by 10% by 2020</p>

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**SB 1275:** One million zero-emission and near-zero-emission vehicles by 2023

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Equity

**General Order 156:** Increase participation of diverse business entities in utility procurement

**CPUC ESJ Action Plan:** Increase investment in clean energy resources to benefit ESJ communities

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## 2.2 RD&D Landscape

The RD&D Program is a vital element of a much larger technology funding ecosystem that includes numerous federal, state, and regional public agencies and a variety of gas industry research consortia. RD&D Program staff works with leading industry professionals and SMEs from these organizations, as well as from universities, national labs, and businesses, to maximize the impact of their investments in promising technologies and products with high commercialization potential.

These relationships enable SoCalGas to engage science and technology experts, other utilities, and industry stakeholders in open dialogues to effectively identify and close knowledge and research gaps, avoid duplication of previous and ongoing research, and mitigate technical, economic, and commercialization risks. This supports the quest to develop products and technologies that reduce customer costs, save energy, increase safety and reliability, improve air quality, and reduce GHG emissions.

Together, information and research concepts are exchanged, project collaborations are developed, partnerships are established, and public and private funding opportunities are actively sought, with the goals of securing additional co-funding and assembling the most capable and impactful team of SMEs to work on any particular project.

### 2.2.1 Public Agencies

At local, state, and federal levels, public agencies play a key role in driving the RD&D Program process, from disseminating project solicitations related to regulatory policy objectives to serving as thought leaders that help shape broad energy strategies. RD&D Program staff regularly work with numerous agencies, including the DOE, CEC, South Coast Air Quality Management District (SCAQMD), San Joaquin Valley Air Pollution Control District (SJVAPCD), the California Air Resources Board, and the Pipeline and Hazardous Materials Safety Administration (PHMSA).

For projects focused on early-stage technologies, public funding programs can significantly reduce many of the risks associated with deploying staff and resources on untested products. This, in turn, can attract high-caliber team members and other leveraged funding to compound the impact of invested dollars. Importantly, if successful, publicly funded projects can serve as springboards to additional public and private funding, larger demonstration projects, and, ultimately, product and technology commercialization.

#### 2.2.1.1 U.S. Department of Energy

The priorities of the DOE are to combat the climate crisis, create clean energy union jobs, and promote energy justice.<sup>14</sup> Annually, the DOE manages hundreds of millions of dollars in energy sector funding. The agency targets its R&D efforts on developing and understanding basic science and transitioning relevant and proven concepts into very-early-stage technology development. In contrast to the SoCalGas RD&D Program, DOE provides a much more limited percentage of its total funding to mid- to late- stage technology

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<sup>14</sup> See Energy.gov, available at <https://www.energy.gov>.

demonstrations and commercialization efforts. DOE funding opportunities allow the SoCalGas RD&D Program to leverage ratepayer funding for greater impact and bring additional federal research funding into California.

The DOE R&D programs most relevant to the SoCalGas RD&D Program's efforts to share knowledge and identify promising funding opportunities include:

- **Building Technologies Office (BTO)** operates under DOE's Office of Energy Efficiency and Renewable Energy (EERE). The organization conducts R&D under five programs: emerging building technologies, residential buildings integration, commercial buildings integration, appliance equipment standards, and building energy codes.
- **Bioenergy Technologies Office (BETO)** also operates under EERE. BETO provides approximately \$100 million in grant funding per year to support bioenergy technologies research. The organization's efforts target reducing the cost of "drop in" biofuels, lowering the cost of biopower, and enabling the production of high-value products from biomass or waste resources.
- **Fuel Cell Technologies Office (FCTO)** focuses on applied research and innovative technology development that is meant to support the advancement of hydrogen and fuel cells. Target end-use sectors include transportation as well as various stationary applications. The organization also seeks to support energy security enhancement and resiliency and to support the growth of a strong domestic economy in emerging technologies. FCTO funds fuel cell advancement projects, as well as projects encompassing hydrogen delivery, storage, technology validation, manufacturing development, safety and standards, market transformation, and other key elements, with approximately \$120 million per year in grant funds available.
- **Advanced Research Projects Agency-Energy (ARPA-E)** advances high-potential, high-impact energy technologies, with a focus on projects that are too early for private-sector investment. Projects focus on game-changing opportunities to generate, store, and use energy. ARPA-E selects projects, in part, on their potential to radically improve U.S. economic prosperity, national security, and environmental health. The program funds \$180 million to \$400 million in projects annually, subject to an annual budget/funding request.
- **Office of Fossil Energy** is responsible for federal research, development, and demonstration efforts on advanced power generation; power plant efficiency; water management; and carbon capture, utilization, and storage technologies, as well as the development of technological solutions for the prudent and sustainable development of the nation's unconventional oil and gas domestic resources.
- **National Energy Technology Laboratory (NETL)** funds a wide array of R&D related to fossil fuels, including natural gas, alternative fuels, liquid fuels, hydrogen fuel cells, carbon capture, and other fossil fuel and alternative fuel and energy technologies. NETL internally funds various ongoing RD&D efforts and provides grant funding to support further development and enhancement of its research portfolio.

RD&D Program staff also work extensively with personnel from many of the DOE's 17 national laboratories, including Oak Ridge National Laboratory, Pacific Northwest National Laboratory (PNNL), Lawrence Livermore National Laboratory, and NREL. These organizations develop advanced energy production and conversion technologies, many of which SoCalGas helps to advance from RD&D scale to full commercialization.

### 2.2.1.2 California Energy Commission

The CEC is the state's primary energy policy and planning agency. The CEC plays a critical role in creating the energy system of the future—one that is clean, modern, and ensures that the fifth largest economy in the world continues to thrive. In pursuit of this goal, the CEC offers numerous funding programs, with a focus on supporting projects, technologies, and products that help the state achieve its critical energy-related goals and objectives. RD&D Program staff regularly participate in workshops presented by the Natural Gas

Research & Development Program and the Electric Program Investment Program (EPIC) and co-fund projects funded by these programs, including several currently underway.

The CEC allocates its funding across multiple funding programs, including several of direct relevance to the RD&D Program:

- **Natural Gas Research & Development Program**  
The Natural Gas R&D Program invests approximately \$24 million per year in projects in the areas of renewable energy and advanced generation, natural gas infrastructure safety and integrity, energy efficiency, transportation research, and energy-related environmental research. Projects are focused on research that is close to demonstration or commercialization.
- **Food Production Investment Program (FPIP)**  
FPIP allocates approximately \$60 million per year in grant funding to California's food producers to reduce GHG emissions. Funding is derived from the California Climate Investments Program, a statewide investment initiative that uses cap and trade monies to reduce GHG emissions, strengthen the economy, and improve public health and the environment. FPIP prioritizes projects that reduce natural gas consumption and has supported optimization and efficiency improvements for natural gas end-users. SoCalGas has previously leveraged FPIP co-funding to support development of technologies that generate heat from renewable resources.
- **Electric Program Investment Charge (EPIC) Program**  
EPIC allocates approximately \$130 million annually to expand renewable energy; build a safe and resilient electricity system; advance electric technologies for buildings, business, and transportation; enable a more decentralized electric grid; improve the affordability, health, and comfort of California's communities; and support California's local economies and businesses. EPIC specifically seeks to provide benefits to ratepayers of California's investor-owned electric utilities. SoCalGas collaboratively provides co-funding opportunities to help technology developers take advantage of EPIC funding, especially concerning the integration of natural gas, renewable natural gas (RNG), and hydrogen into the electricity sector. In this way, SoCalGas's RD&D program is a solution provider across the entire energy space, from fuels to electricity.
- **Clean Transportation Program (CTP)**  
CTP invests up to \$100 million per year in various transportation and transportation fuel projects statewide. The program specifically provides funding for EVs and hydrogen refueling infrastructure, MHD natural gas vehicles (NGVs), biofuels, and associated workforce development.

### 2.2.1.3 California Air Resources Board

CARB is California's clean air agency. The stated goals of CARB include attaining and maintaining healthy air quality, protecting the public from exposure to toxic air contaminants, and providing innovative approaches for complying with air pollution rules and regulations.

CARB sponsors basic research that provides a scientific basis for the organization's policies and programs. Since 1971, CARB's research program has helped to identify health-based air quality standards, reduce exposure to air pollution, and implement GHG emissions reductions to support California's climate policies. Currently, CARB's research program is helping the agency to work toward multiple air quality and climate goals, including achieving attainment for ozone and PM<sub>2.5</sub>, meeting 8-hour ozone standards, further reducing GHG emissions, and ultimately reaching and surpassing carbon neutrality. CARB funds dozens of air quality

and atmospheric science programs.<sup>15</sup> CARB's life cycle analysis models, such as the CA-GREET3.0 Model and Tier 1 Simplified Carbon Intensity Calculators,<sup>16</sup> are particularly important to the success of R&D efforts.

CARB's research program provides for internal research as well as external contracted research projects. CARB's current research plan identifies specific project categories for the organization's 2021–2022 fiscal year. CARB is allocating nearly \$4.2 million for the following project categories:

- Studies that quantify the health impacts of air pollution exposure on vulnerable populations (\$875,000)
- Health and air quality impacts of wildfire and PM2.5 (\$2,300,000)
- Incentivizing zero emission, high occupancy, and new mobility options (\$975,000)

RD&D Program staff regularly participate in workshops presented by CARB and co-fund projects funded by CARB, including several currently underway.

#### 2.2.1.4 South Coast Air Quality Management District

SCAQMD supports R&D efforts that specifically target pollutant emissions in its service area. SCAQMD focuses extensively on developing and demonstrating technologies that reduce criteria air pollutant emissions, especially ozone precursors and PM. These efforts target reducing air emissions and, ultimately, alleviating non-attainment status for SCAQMD's service area. SCAQMD works as a frequent collaborator with SoCalGas. The two organizations have worked closely on multiple emissions reduction projects—from the conversion of diesel-powered vehicles to natural gas to the development of larger and more efficient heavy-duty natural gas engines. SCAQMD manages \$37.3 million per year in research funding available, in part from a \$1 surcharge on vehicle registration fees within its service area. The organization leverages cooperative relationships within private industry, academic and research institutions, technology developers, and government agencies to develop and demonstrate technologies that reduce pollutant emissions and generally support improved air quality.

#### 2.2.1.5 San Joaquin Valley Air Pollution Control District

The SJVAPCD operates the Technology Advancement Program (TAP), which seeks to encourage and develop new emissions reduction technologies. SJVAPCD implements TAP to encourage the development of critical technology that will help California's Central Valley reach attainment. SJVAPCD has divided the TAP into the following technology focus areas:

- **Alternatives to Open Burning**, including projects that focus on technologies and practices that minimize or eliminate emissions from the open burning of agricultural fields.
- **Renewable Energy**, with a focus on overcoming the barriers that prevent the use or adoption of zero-emissions renewable energy sources or that reduce emissions from renewable energy systems, making them cleaner to operate than comparable conventional fossil-fueled systems.
- **Waste Solutions**, including projects that focus on waste systems or technologies that minimize or eliminate emissions from existing waste management systems and processes, including waste-to-fuel systems, dairy digesters, and other biofuel applications.
- **Mobile Sources**, with projects that demonstrate zero- or near-zero-emissions solutions for mobile sources, with an emphasis on the movement of goods and people, off-road equipment, and agricultural equipment.

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<sup>15</sup> CARB A - Z Index of All Top-Level Programs / Topics can be accessed at: <https://ww3.arb.ca.gov/html/all.htm>.

<sup>16</sup> CARB LCA Models are described at: <https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation>.

Through the SoCalGas Regional Public Affairs (RPA) team, RD&D Program staff track policies and priorities set by SJVAPCD to guide research planning efforts.

### **2.2.2 Universities**

SoCalGas closely collaborates with scientists, engineers, and other academics at some of our nation's most prominent universities, including Stanford University, Caltech, and UC Davis, UC Riverside, and UC Irvine. These professionals perform fundamental science work through lab- and bench-scale applied research on a variety of critical energy topics, including fuel cell development, carbon-free hydrogen production and energy storage, and carbon capture and utilization. University collaborators also possess expertise in modeling, techno-economic analysis, and lifecycle analysis. These areas are of immense importance to the evaluation, development, and demonstration of cleaner, safer, affordable, and more reliable energy solutions. On many projects, universities serve as ideal technology demonstration sites.

SoCalGas also engages with diverse populations at local California State Universities, California Community Colleges, and local private universities in order to foster new researchers. These universities have significant first-generation student populations and many students from ESJ communities.

### **2.2.3 National Laboratories**

The U.S. National Laboratories and Technology Centers are a system of facilities and laboratories overseen by the DOE to advance science and technology. Researchers and scientists at the 17 national labs tackle the critical scientific challenges of our time—from combating climate change to discovering the origins of our universe—and possess unique instruments, equipment, and testing facilities. National labs are unequaled in their ability to address large-scale, multifaceted, and complex R&D challenges with a multidisciplinary approach that emphasizes translating basic science to innovation. SoCalGas regularly engages national lab personnel for subject matter expertise, guidance, and collaboration in developing and executing research projects. Through collaboration with national labs, SoCalGas often co-funds projects supported by the DOE, amplifying the impact of RD&D Program funds for maximum leverage. In many cases, SoCalGas also obtains licensing or intellectual property (IP) rights, which can generate revenue and offset RD&D Program costs.

### **2.2.4 Businesses**

At its core, the RD&D Program is about developing and promoting practical applications to overcome challenges facing the energy sector in alignment with California's decarbonization goals. To help ensure that the new technologies and products supported by SoCalGas advance to real-world applications and markets, RD&D Program staff leverage their connections, knowledge, and expertise by working closely with leading equipment manufacturers and global technology developers to demonstrate new technologies in large-scale and/or long-term pilot demonstration projects under real-world conditions. These demonstrations constitute the final stages of validation before commercial launch.

### **2.2.5 Research Consortia**

RD&D Program staff have developed strong ties with several research consortia focused on the gas energy industry. The membership of many of these organizations consists of utility companies across North America. Typically, these consortia serve member utilities by facilitating technical collaboration and pooling technical and financial resources to collectively address ongoing or anticipated technical or scientific challenges in the gas industry. Together, these organizations and the RD&D Program exchange information and research concepts, collaborate on project development, establish partnerships, and actively seek public and private funding opportunities, with the goals of securing additional co-funding and assembling the most capable and impactful team of subject matter experts to work on any particular project. The consortia maintain the right

to direct funds to the projects of their choosing, but frequently collaborate with the RD&D Program. OTD, UTD, and NYSEARCH all have the option to propose company-specific research projects.

**Table 8:** Forecast 2022 membership dues for research consortia.

Consortium	Fee/Dues
Northeast Gas Association (NGA)/NYSEARCH	\$72,250
Operations Technology Development (OTD)	\$750,000
PRCI	\$150,000
Sustaining Membership Program (SMP)	\$100,000
UTD	\$350,000

By working closely with these and other similar organizations, RD&D Program staff can share both knowledge and funding with other utilities and researchers to develop and execute impactful projects. Coordination of work between these organizations and access to technical libraries also greatly reduces the odds of reproducing previously completed work or duplicating work currently underway.

To facilitate collaboration with research consortia, the RD&D Program is a member of five subscription-based organizations:

1. **Northeast Gas Association (NGA)/NYSEARCH:** a collaborative research suborganization within the Northeast Gas Association that serves 20 gas utility member companies. Members of NYSEARCH, primarily North American gas distribution companies, voluntarily participate in projects focused directly on needs specific to the member companies and the gas industry as a whole.
2. **Operations Technology Development:** a not-for-profit organization, comprising 26 gas utility members that serve over 60 million gas consumers in the United States and Canada, representing 75% of the households served by gas. OTD combines the interests, expertise, and resources of its members to develop advanced operations and pipeline technologies for the gas industry.
3. **Pipeline Research Council International:** a community of the world’s leading pipeline companies, vendors, service providers, equipment manufacturers, and other organizations supporting the gas industry. PRCI’s research focuses directly on gas and oil transmission pipeline issues.
4. **Sustaining Membership Program (SMP):** a collaborative R&D program with two segments, Utilization and Operations. Its 28 gas utility members support research projects focused on gas delivery, energy utilization, environmental science, and renewable energy. SMP develops technology through the “proof of concept” phase, at which point the most promising technologies are continued through short- to mid-term R&D programs implemented by organizations such as OTD and UTD.
5. **Utilization Technology Development:** a 20-member consortium of utilities in the United States and Canada, representing 37 million gas customers in North America. Its goal is to develop new technologies that help gas consumers save money, reduce emissions, improve efficiencies, and optimize their gas use.

### 2.2.6 SoCalGas RD&D Program

Within this rich funding ecosystem, the RD&D Program plays a unique role. Where many of these organizations mentioned above focus on national and statewide needs, the RD&D Program concentrates on

the needs of its many residential, commercial, and industrial ratepayers in Southern California. This focus enables the RD&D Program to better serve its ratepayers while also helping to develop products and technologies that can ultimately have state, national, and even global importance.

The SoCalGas RD&D Program has many strengths. SoCalGas is dedicated to engaging with and supporting the communities it serves, providing energy, time, and financial support in areas where it can make a difference. And because SoCalGas serves residential, commercial, and industrial gas customers in Southern California as its primary line of business, RD&D Program staff have access to the existing infrastructure, information, and expertise of the entire company, including an intimate knowledge of customer challenges, needs, and desired benefits. The company's existing infrastructure—as well as the relationships the company has built with its customer base and regional public agencies—also provides access to a rich base of potential demonstration sites within the region.

Importantly, the RD&D Program has the ability to act nimbly, providing funding to innovative new products and technologies that federal, state, and regional agencies cannot support due to slower funding cycles. Furthermore, the RD&D Program is positioned to supplement and complement the work of other organizations, stepping in to fund early-stage research or middle- to late-stage technology development that other organizations cannot support.



## 3 Stakeholder Input

### 3.1 Stakeholder Outreach

The RD&D Program works closely with industry professionals and SMEs at universities, national labs, public agencies, businesses, and industry research consortia to maximize the impact of its investments in 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 in order to achieve the RD&D Program goals.

**Table 9:** RD&D Program staff conducted stakeholder interviews with more than 50 individuals from 20 different organizations in early 2021.

#### 2022 Stakeholder Organizations Interviewed

California Department of Food and Agriculture	Northwest Natural Gas
California Energy Commission	Pacific Gas and Electric
California Governor's Office of Business and Economic Development	Pipeline and Hazardous Materials Safety Administration
California Institute of Technology	Port of Los Angeles
California State University, Los Angeles	San Diego Gas & Electric
Gas Technology Institute	South Coast Air Quality Management District
Lawrence Berkeley National Laboratory, Energy Conversion Group	Stanford Natural Gas Institute
Los Angeles County Metropolitan Transportation Authority	UC Riverside
Low Carbon Resources Initiative	U.S. Department of Energy, ARPA-E
Northeast Gas Association	U.S. Department of Energy, Bioenergy Technology Office

Conversations with these stakeholders and SMEs are ongoing throughout the year, but in preparation for the 2022 funding allocations, RD&D Program staff also conducted a series of targeted interviews with more than 50 people from 20 different organizations in the first quarter of 2021. 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.

### 3.2 Annual Stakeholder Workshop

On April 14, 2021, the RD&D Program staff hosted an online workshop to present the results of the previous year's program and obtain input regarding proposed spending allocations for 2022. The workshop was attended by 165 individuals from a wide variety of organizations.

#### 2022 Annual Stakeholder Workshop Attendee List

ADL Ventures	Momentum
Alexander Economics	MXV Ventures
Altrix	National Association for the Advancement of Colored People, Riverside 1059

ATCO	NASA Jet Propulsion Laboratory
Blue Frontier, LLC	National Renewable Energy Laboratory
Buchalter, A Professional Corporation	NGV America
Burns & McDonnell	Northridge East Neighborhood Council
California Fuel Cell Partnership/Frontier Energy	Northwest Energy Efficiency Alliance
California Governor's Office of Business and Economic Development, Zero-Emission Vehicle (ZEV) Market Development	NW Natural
California Public Utilities Commission	NYSEARCH/NGA
California State University, Los Angeles	Oak Ridge National Laboratory
Calpine	Pacific Gas and Electric
Capstone Turbine Corporation	Pipeline and Hazardous Materials Safety Administration
Center for Environmental Research and Technology	Pipeline Research Council International
Century 21 Ludecke Inc.	PK Global
Clean Energy Fuels	Plug and Play
Community Services Employment Training	Proteus Inc.
Cummins, Inc.	ReactWell, LLC
E2 Consulting Engineers, Inc.	Resource Innovations
Earthjustice	San Diego Gas & Electric
Enbridge Gas Inc.	Scaled Power, Inc.
Energy Solutions Center	Sempra Energy
Gas Technology Institute	Sempra LNG LLC
Hexagon Agility	Society of Professional Hispanic Engineers
Hyperlight Energy	South Coast Air Quality Management District
Imperial Irrigation District	Southwest Research Institute
Innovative Environmental Solutions, Inc.	Stanford University
Istanbul Gas Distribution Industry and Trade Joint Stock Company	Stone Mountain Technologies, Inc.
Kern Oil & Refining Co.	Tenaska Marketing Ventures
L2 Services LLC	Tosdal, APC
Latino Chamber of Commerce of Compton	Triple E Energy Advisors Inc.
Lawrence Berkeley National Laboratory	UC Irvine
Los Angeles Department of Water and Power	UC Riverside
Los Angeles Neighborhood Council Coalition	Yinsight, Inc.
Metal One America	

### 3.3 Stakeholder Input

To host the workshop, the RD&D Program engaged the services of Momentum—a Sacramento-based consulting firm with expertise in strategic planning, public fund development, grant and project management, and commercialization—and its affiliate, MXV Ventures. John Meissner, Managing Director of MXV Ventures, led the workshop with assistance from RD&D Program staff. During the five-hour workshop, Mr. Meissner and RD&D Program team members presented the following topics:

- 2020 in Review
- Program Status and Updates for 2021
- Draft research plan for 2022

At the end of each section of the presentation, Mr. Meissner accepted questions and comments. He and RD&D Program staff addressed questions during the workshop. To ensure that attendees were fully informed, a link to the workshop recording was emailed to all registered attendees on the date of the workshop. SoCalGas also posted a link to the workshop recording on the RD&D Program web page.<sup>17</sup> 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.

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<sup>17</sup> See SoCalGas, Research and Development, available at <https://www.socalgas.com/clean-energy/research-and-development>.

## 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 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.<sup>18</sup>

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.<sup>19</sup>*

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.<sup>20</sup>*

### 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. It 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 2020, the company awarded \$884.2 million in SoCalGas contracts to more than 550 certified DBEs, the highest amount in the company's history. This represents 41.3% of the company's total purchases with suppliers and includes 135 new diverse firms added in 2020. Importantly, this total marks the 28<sup>th</sup> consecutive time that SoCalGas exceeded the CPUC's goal of 21.5% of total procurement of goods and services from women, minority, service-disabled veteran, and LGBT-owned businesses.<sup>21</sup>

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<sup>18</sup> U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Low-Income Household Energy Burden Varies Among States — Efficiency Can Help In All of Them* (December 2018), available at [https://www.energy.gov/sites/prod/files/2019/01/f58/WIP-Energy-Burden\\_final.pdf](https://www.energy.gov/sites/prod/files/2019/01/f58/WIP-Energy-Burden_final.pdf).

<sup>19</sup> Fourth National Climate Assessment, *Volume II: Impacts, Risks, and Adaptation in the United States*, available at <https://nca2018.globalchange.gov/#>.

<sup>20</sup> *Id.*

<sup>21</sup> PRNewswire, *Diverse Businesses Awarded Over \$884 Million in SoCalGas Contracts in 2020, 42% of Total Spending* (March 8, 2021), available at <https://www.prnewswire.com/news-releases/diverse-businesses-awarded-over-884-million-in-socialgas-contracts-in-2020-42-of-total-spending-301242570.html>.

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 can 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, and a VALOR program that helps provide a smooth transition for newly hired SoCalGas veteran/active military employees.

SoCalGas' dedication to a diverse and inclusive workplace has been acknowledged with the following awards for our parent company, Sempra Energy:<sup>22</sup>

- Human Rights Campaign: Best Places to Work for LGBTQ Equality
- National Organization on Disability: Leading Disability Employer Seal
- DiversityInc's Top Utility
- Black EOE Journal: Best of the Best List
- Hispanic Network Magazine: Best of the Best List
- National Association for the Advancement of Colored People (NAACP): Equity, Inclusion and Empowerment Index
- Thomas Reuters Diversity & Inclusion Index: #24 of top 100 publicly traded companies

### **4.3 Equity in the RD&D Program**

The RD&D Program 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. Equity is one of the program's core values and a factor it considers in every funding allocation decision.

Our short-term goals are to increase our engagement with residents, businesses, and academic Institutions within ESJ communities and to continually grow the number of projects the RD&D Program supports in those locations. Ultimately, the goal is to ensure that the benefits of decarbonization and clean energy do not become luxuries for the wealthy but are widely available and accessible to all Californians.

One of the key drivers of RD&D Program investment is the CPUC's ESJ Action Plan, which seeks to, among other things, increase investment in clean energy resources to benefit ESJ communities, especially to improve local air quality and public health.

### **4.4 2021 Equity Progress Report**

In the 2021 Research Plan, the RD&D Program set the following goals for 2021.

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<sup>22</sup> SoCalGas, *Diversity at SoCalGas, Learn About Our Commitment to Embracing A Diverse Workforce*, available at <https://www.socalgas.com/careers/diversity>.

Table 10: Status of equity goals from the 2021 Research Plan.

Goal	Status
<b>Commit to long-term relationship-building with key representatives of ESJ Communities throughout California.</b>	Complete.
<b>Prepare and present educational material to members of DACs and LICs about the RD&amp;D Program and its major programs and subprograms and request feedback.</b>	Program staff prepared educational material about the RD&D Program for members of ESJ communities and, in collaboration with the SoCalGas RPA team, co-launched the ESJ outreach program, identifying approximately 20 CBOs to target for 2021 presentations and solicitation of input on potential research needs.
<b>Connect with regional California universities to identify researchers engaged with members of DACs and LICs. Potential target universities include: California State University (CSU), Los Angeles Center for Engagement, Service, and Public Good, and UCLA Luskin Center.</b>	Program staff interviewed experts, including researchers at the University of California, Los Angeles (UCLA) Luskin Center for Innovation and a Senior Equity Analyst at the CPUC, to seek guidance on developing the RD&D Program’s Equity Engagement Plan. Through RPA, the RD&D Program connected with academic experts at a variety of institutions with strong backgrounds in public policy and diversity, including CSU Los Angeles, Cal State Fullerton, CalPoly Pomona, University of Southern California Price School of Public Policy, and Chapman University Center for Demographics and Policy.
<b>Leverage existing connections within Air Districts, CARB, and CEC to identify promising contacts within ESJ Communities.</b>	RD&D Program staff are tracking the proceedings of the CEC's Disadvantaged Community Advisory Group (DACAG) and SCAQMD's AB 617 Community Steering Committee.
<b>Establish metrics and goals to demonstrate progress, including presenting five non-technical RD&amp;D presentations to California CBOs in 2020-2021.</b>	<p>RD&amp;D Program staff have completed three community engagement sessions in 2021. Two additional session will be scheduled in Q3/Q4 of 2021.</p> <ol style="list-style-type: none"> <li data-bbox="753 1287 1403 1444">1. <b>Session #1 – February 24th, 2021</b> Representatives from 11 CBOs, including HomeAid America, Orange County; El Concilio Family Services; Black Voice Foundation; and the National Association for the Advancement of Colored People.</li> <li data-bbox="753 1455 1403 1581">2. <b>Session #2 – March 10th, 2021</b> Representatives from seven CBOs, including Asian Youth Center, Community Action Partnership of Kern, and Greater Lakewood Chamber of Commerce.</li> <li data-bbox="753 1591 1403 1749">3. <b>Session #3 – May 19th, 2021</b> Representatives from six colleges and universities, including UC Riverside, CSU Long Beach, Cal Poly Pomona, CSU Fullerton, UC Irvine, and CSU Los Angeles.</li> </ol>

## 4.5 2022 Equity Engagement Plan

By the end of 2021, RD&D Program staff anticipate completing a formal RD&D Program Equity Engagement Plan. In 2022, staff will plan on implementing the plan. Anticipated activities include:

- Requiring all RD&D Program funding recipients to complete an Equity Engagement Survey.
- Working with other units within SoCalGas, such as Diversity, Equity, and Inclusion, Supplier Diversity, Community Relations, RPA, and Sustainability to identify best practices and leverage established programs to improve engagement between the RD&D Program and the community.
- Establishing equity metrics to measure benefits to ESJ communities and mechanisms for tracking them, including by project, when applicable (Section 1.5). Possibilities include:
  - Number of new, completed, and total projects located in ESJs
  - Number of projects with Principal Investigators from ESJ communities or other underrepresented groups
- Create one or more project spotlights featuring an RD&D Program project that benefited an ESJ community or another underrepresented group or has the potential to benefit such groups when commercialized.

In Resolution G-3573, the CPUC stated:

*...More quantitative detail is needed in future plans to measure the impact of RD&D projects on disadvantaged and low-income communities in terms of job creation and other economic development.<sup>23</sup>*

RD&D Program staff believe, however, that short-term metrics such as job creation and other economic development do not adequately convey the potential positive impact that RD&D Program projects can have on ESJ communities. RD&D Program projects tend to be short-term projects, demonstrating a given technology in the lab or field over the course of several months or perhaps one to two years. As such, they do not typically result in significant short-term hiring, although they can spur some economic development through local and regional spending on equipment, materials, and labor.

The real value of RD&D Program projects lies in their ability to develop products and technologies that, when scaled up or operationalized, can increase the long-term reliability and safety of energy, while reducing its associated costs and environmental impact.

R&D Program investment also provides long-term societal benefits by spurring productivity, invention, and patenting activity. These investments today have the potential to significantly improve human life by making a down payment on addressing challenges such as climate change.<sup>24</sup>

Although some short-term metrics—such as total number of funded projects in ESJs or percent of RD&D budget allocated to DBEs—do exist for tracking the positive impact of RD&D projects on ESJ communities, the RD&D Program believes that long-term metrics are ultimately a better approach to gauging the success of the RD&D Program. Examples of such metrics include the potential, when scaled up, to:

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<sup>23</sup> Resolution G-3573 (March 18, 2021) at 9. *See also id.* Ordering Paragraph 3 at 16 ("Continue to increase its focus on equity by including detail on how it will measure impacts to communities and providing additional detail on engagement with community-based organizations.").

<sup>24</sup> Prepared by PwC on behalf of Breakthrough Energy Ventures, *Impacts of Federal R&D Investment on the US Economy* (September 2020), available at <https://www.breakthroughenergy.org/-/media/files/bev/bepwcreport09162020.pdf>, September 2020.

- Reduce GHG and NOx emissions in ESJ communities
- Reduce the cost of energy in ESJ communities
- Increase the reliability of energy delivery in ESJ communities



## 5 New in 2022

### 5.1 New Subprogram Categories

As an element of the 2022 funding allocation and justification process, SoCalGas refreshed its subprogram categories to balance the clear delineation of critical research areas with the desire to maintain the flexibility to address new and unforeseen technologies and research directives. During the annual workshop, RD&D Program staff requested the following modifications to the existing subprograms and received positive feedback from stakeholders.

**Table 11:** Overview of changes to the RD&D Program's Subprograms from 2021 to 2022.

Programs	2021 Subprograms	2022 Subprograms	Rationale
Low Carbon Resources	Renewable Gas Production Low Carbon Hydrogen Production	Renewable Gas Production	The two proposed subprograms reflect stakeholder feedback and better align with the broader research community and public policy.
	Low GHG Chemical Processes	Carbon Capture, Utilization, & Sequestration	
Gas Operations	Environmental & Safety Operations Technology	Environmental & Safety Operations Technology	No change.
	System Design & Materials	System Design & Materials	
	System Inspection & Monitoring	System Inspection & Monitoring	
Clean Transportation	Off-Road On-Road	Off-Road On-Road	On-Road subprogram will focus only on zero-emission MHD vehicles and equipment. <sup>25</sup>
	Refueling Stations	Refueling Stations	
	Onboard Storage	Onboard Storage	
Clean Generation	Distributed Generation Integration & Controls	Distributed Generation Integration & Controls	No change.
Customer End-Use Applications	Commercial Food Service Residential Appliances	Commercial Food Service Residential Appliances	No change.
	Commercial Applications	Commercial Applications	
	Industrial Process Heat	Industrial Process Heat	
	Advanced Innovation	Advanced Innovation	

### 5.2 ASPIRE 2045

As noted in Section 1.1, SoCalGas recently announced ASPIRE 2045, a sustainability strategy that includes a bold commitment to achieve net-zero GHG emissions in the operations and delivery of energy by 2045. Innovation and the rapid development of new technologies will be vital to the success of this effort.

Three SoCalGas capabilities are integral to achieving California's energy transition and net-zero goals:

<sup>25</sup> This change is in response to Governor Newsome's Executive Order N-79-20 (September 23, 2020), which requires 100% zero-emission off-road vehicles and equipment by 2035 where feasible.

- **Decarbonization:** Reducing carbon intensity across all economic sectors is foundational to achieving net-zero. It requires energy efficiency, renewable electricity, renewable gases, long duration storage, carbon management, and other technologies to be viable at scale.
- **Diversification:** Developing a diversified portfolio of clean energy sources, distributed networks, tools, and applications is the only way to achieve society’s clean energy goals. Diversification also serves as a necessary risk management tool, delivering resiliency to the system and protecting against the uncertainties of the future.
- **Digitalization:** Deploying advanced technologies and analytics to improve planning, safety, resiliency, and the integration of real-time information to benefit participants across the energy value chain.

The intersection of clean energy technologies, sound policy, and capital investments will accelerate the affordable energy transition. The energy transition requires expanding on proven and new technologies in energy efficiency, RNG, renewable electricity, fuel cells, hydrogen, and carbon management. The RD&D Program commits to investing in a diverse portfolio of technologies and applications to decarbonize.

### 5.3 Response to Stakeholder Input

Through ongoing conversations throughout the past year and an intensive outreach process conducted during the first quarter of 2021, RD&D Program 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 Program staff confirmed that its 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. Five key themes emerged from the collection of stakeholder input:

- **Decarbonization of the Pipeline via Hydrogen**  
Virtually every stakeholder spoken with indicated support for or strongly advocated the exploration of all aspects of using hydrogen to decarbonize the pipeline, transportation, and end-use applications.<sup>26</sup> Although the RD&D Program is already strongly committed to R&D work associated with hydrogen, this input spurred the RD&D Program to 1) commit to use biomethane for the demonstration of advanced steam methane reforming (SMR) technologies and 2) increase its involvement in methane pyrolysis research with national labs, such as Pacific Northwest National Lab (PNNL), and with start-ups/private companies, such as C-Zero and Xerox/Palo Alto Research Center.
- **The Need for Greater International Collaboration**  
Many stakeholders also noted that many of the clean energy technologies being explored in the United States have been explored at greater depth in Europe and Asia. As a result, many encouraged RD&D Program staff to increase their efforts to collaborate with foreign entities researching, developing, and demonstrating similar technologies and products aimed at facilitating the energy transition.<sup>27</sup>

RD&D Program staff have several international collaborations and are exploring others, including:

<sup>26</sup> See Appendix A: A1, A5, A9, A11 A17, A18, A20, A21, A26, A27, A34, A38, A39, A41, B2, B4–7, B16, B22–25, B27–31, B34–37, B39, B43–46, B49, B51, D4, D10.

<sup>27</sup> See Appendix A: F1, G2, M11, and Appendix B: Q5.

- Membership in the international research consortium PRCI
- GTI Hydrogen Drone Demonstration with Doosan Mobility Innovations in South Korea
- H2@Scale Texas and Beyond with Mitsubishi Heavy Industries (Japan) and Air Liquide (France)
- GTI Hydrogen Fuel Cell Yard Truck Port of Los Angeles Demonstration in collaboration with HTEC (Canada) and Ballard Power Systems (Canada)
- Electrochemical Hydrogen Compression and Purification Skid Procurement with HyET Hydrogen (Netherlands)
- TCF-19-17586 LLNL Composite Sorbents - Enabling Economical Biomethane with Xebec (Canada)

Moving forward, RD&D Program staff intend to pursue greater collaboration with international project teams, particularly those exploring large-scale projects, such as decarbonizing entire municipalities (Appendix A: A39, Appendix A: G2).

- **A Desire for More Knowledge Transfer**

Another commonly echoed comment was a desire among stakeholders to know more about the RD&D Program and the projects it funds.<sup>28</sup> In response, RD&D Program staff will continue to refine their current knowledge transfer and outreach activities, including:

- Q1 Stakeholder Outreach Interviews
- Annual Stakeholder Workshop
- Annual Report
- Research Webinars
- Presentations at industry conferences, such as:
  - Advanced Clean Transportation (ACT) Expo
  - Cleantech Forum
  - VerdeXchange
  - Sustain SoCal Annual Conference and Expo

- **Gas Heat Pump Water Heaters**

Many stakeholders also indicated a desire for more R&D work around heat pump water heaters.<sup>29</sup>

In response, RD&D Program staff will continue to identify and assess Gas Heat Pump research projects, particularly through research consortia and participation in the North American Gas Heat Pump Collaborative.

- **Fuel Cells and Combined Heat and Power (CHP)**

Several stakeholders expressed a need for research around resilient on-site power generation technologies such as fuel cells and CHP systems.<sup>30</sup>

In response, the RD&D program will direct more funds towards the development and demonstration of fuel cell and CHP technologies. Projects in this area will also investigate hydrogen blending in these systems.

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<sup>28</sup> See Appendix A: H for specific input.

<sup>29</sup> See Appendix A: A14, D20, L2, Appendix C: Q16.

<sup>30</sup> See Appendix A: A13, A19, A30, A40, C2, L5.

## 6 Proposed 2022 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 2022. The total authorized funding for 2022 is \$16,494,000.<sup>31</sup> Of that total, RD&D Program staff will allocate approximately 10% or \$1,649,400 to program administration. Activities in this category include management and administrative labor, reporting, the annual workshop and research plan, stakeholder outreach, equity engagement, and improvements to the program database and website. Any unspent Program Administration funds will be reallocated to the Programs on a pro-rata basis to support additional research projects. The remaining authorized budget, approximately \$14,845,000, is allocated across the subprograms.

**Table 12:** RD&D Program Proposed 2022 Funding Allocations by Program and Subprogram.

<b>Programs</b>	<b>Program Funding</b>	<b>Subprograms</b>	<b>Subprogram Funding</b>
Low Carbon Resources	\$5,492,502	Renewable Gas Production	\$3,295,501
		Carbon Capture, Utilization, & Sequestration	\$2,197,001
Gas Operations	\$3,562,704	Environmental & Safety	\$712,541
		Operations Technology	\$534,406
		System Design & Materials	\$1,425,081
		System Inspection & Monitoring	\$890,676
Clean Transportation	\$2,078,244	Off-Road	\$623,473
		On-Road	\$623,473
		Refueling Stations	\$415,649
		Onboard Storage	\$415,649
Clean Generation	\$1,632,906	Distributed Generation	\$1,224,680
		Integration & Controls	\$408,226
Customer End-Use Applications	\$2,078,244	Commercial Food Service	\$145,477
		Residential Appliances	\$665,038
		Commercial Applications	\$311,737
		Industrial Process Heat	\$831,298
		Advanced Innovation	\$124,695
Program Administration	\$1,649,400		
<b>Total</b>	<b>\$16,494,000</b>		

After careful review and consideration of stakeholder input, RD&D Program staff identified the subprograms

<sup>31</sup> Any over- or under-spend from 2021 will be applied to 2022 in accordance with Resolution G-3573 at 13.

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.

## 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 RNG, displacing conventionally sourced pipeline gas, and capturing and permanently removing atmospheric GHG emissions.

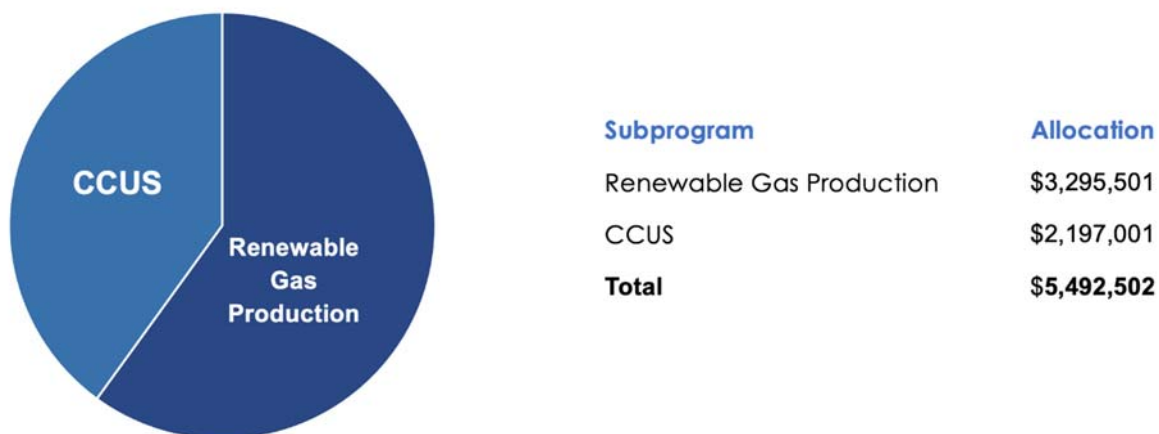
RD&D Program personnel in the Low Carbon Resources program area focus their efforts on the following goals:

- 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.

In 2021, the Low Carbon Resources program consisted of three subprograms. In response to stakeholder input and a desire for better alignment with the broader research community and California public policy, program staff propose to consolidate their activities into two subprograms: 1) Renewable Gas Production and 2) Carbon Capture Utilization and Sequestration (CCUS). Low Carbon Resources projects can fall within one or both subprograms.

2021 Subprograms	Proposed 2022 Subprograms
Renewable Gas Production	Renewable Gas Production
Low Carbon Hydrogen Production	
Low GHG Chemical Processes	Carbon Capture, Utilization, & Sequestration (CCUS)

### 7.1 Proposed 2022 Low Carbon Resources Funding Allocation



**Figure 2:** Visual Summary of proposed 2022 Funding Allocations for Subprograms within the Low Carbon Resources Program.

## 7.2 Renewable Gas Production

### 7.2.1 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.

### 7.2.2 Subprogram Benefits

Benefit	Explanation
<b>Reliability</b>	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 <sub>2</sub> emissions to produce RNG via methanation processes. In 2020, 1,586,500 megawatt-hours of electricity were curtailed in California, according to the California Independent System Operator. <sup>32</sup> This translates to approximately 32,000 metric tons of hydrogen production from electrolysis and, correspondingly, 168,000 metric tons of CO <sub>2</sub> that potentially could have been recycled to methane from methanation pathways. Additionally, hydrogen and RNG can be produced from biomass, a clean, reliable, locally available energy resource.
<b>Safety</b>	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. Additionally, small, modular onsite hydrogen generation systems contain relatively small amounts of hydrogen and can more easily be turned off should a plant upset occur.
<b>Improved Affordability</b>	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.

<sup>32</sup> California ISO, *Wind and Solar Curtailment December 30, 2020*, available at [http://www.caiso.com/Documents/Wind\\_SolarReal-TimeDispatchCurtailmentReportDec30\\_2020.pdf](http://www.caiso.com/Documents/Wind_SolarReal-TimeDispatchCurtailmentReportDec30_2020.pdf).

Benefit	Explanation
<b>Environmental: Reduced GHG Emissions</b>	Hydrogen and RNG production can displace fossil-sourced hydrocarbons, thereby reducing, mitigating, or eliminating associated CO <sub>2</sub> and methane emissions. Carbon negative hydrogen production cycles are now being deployed that directly remove CO <sub>2</sub> from the atmosphere. <sup>33</sup>
<b>Environmental: Improved Air Quality</b>	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 thermocatalytic processes that eliminate NO <sub>x</sub> and PM emissions.

### 7.2.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 eliminate intrinsic power system conversion and transmission losses, costly transmission system upgrades, and competition with electricity end-users. Additionally, 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<sub>2</sub> with methanation—either via conventional thermocatalytic methanation, electrocatalytic processes, or the use of biological methanogens—is a key area of research that can be deployed broadly to capture and convert biogenic CO<sub>2</sub> emissions from bio-digesters, ethanol plants, landfills, and biomass gasifiers into RNG. Thus, methanation technologies can expand the availability of renewable gas and thereby 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<sub>2</sub>. 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<sub>2</sub> 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.

<sup>33</sup> Clean Energy Systems, *Carbon-Negative Energy (CNE)*, available at <https://www.cleanenergysystems.com/carbon-negative-energy>.



- 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 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.
- 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.

#### 7.2.4 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 <sub>4</sub> ) 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

#### 7.2.5 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 the 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 Carbon Capture, Utilization, and Sequestration

### 7.3.1 Subprogram Overview

This subprogram focuses on carbon capture, utilization, and sequestration (CCUS)—all vital in the fight against climate change. Roughly half of the excess CO<sub>2</sub> 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<sub>2</sub> 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, since the solid carbon produced can be either converted into a useful product or sequestered in solid form, methane pyrolysis will be listed as a standalone category under CCUS.

### 7.3.2 Subprogram Benefits

Benefit	Explanation
Reliability	Leveraging synergies between renewable energy surplus/curtailment, carbon capture, and RNG production from captured CO <sub>2</sub> 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 <sub>2</sub> from the air, resulting in potentially negative overall carbon emissions. Additionally, 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.

### 7.3.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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<sub>2</sub> extraction and capture technologies while meeting the cost and efficiency constraints needed for mass deployment. For example, CO<sub>2</sub> could be captured from biogenic point sources using specialized sorbents to enhance RNG yield and recovery from biodigesters, from industrial point sources to prevent the release of CO<sub>2</sub>-laden flue gas to the atmosphere, from atmospheric sources via direct air capture, and from oceanic carbon sources via CO<sub>2</sub> bipolar membrane electro-dialyzers. All these technologies are at different stages of development and could revolutionize our 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<sub>2</sub> 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<sub>2</sub> into useful products, including:

- Electrochemical and electrocatalytic processes, that is plastics and biofuels production from CO<sub>2</sub> and water using electricity,
- Electro-methanogenesis, that is RNG production from CO<sub>2</sub> and water using electricity, and
- 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<sub>2</sub>. Studies by the Intergovernmental Panel on Climate Change<sup>34</sup> (IPCC) and the California Council on Science and Technology (CCST) have shown that carbon capture and sequestration, or 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.<sup>35</sup> 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<sub>2</sub>. CCS is already being deployed to sequester carbon emissions from large-scale 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. Additionally, 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. This carbon can be used for a wide variety of applications, such as cement additives and carbon nanotubes. This technology has tremendous decarbonization potential as it does not generate any carbon emissions and can therefore reduce the cost of large-scale hydrogen generation while simultaneously offsetting carbon emissions.

#### 7.3.4 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<sub>2</sub> per year by 2045 to achieve state carbon neutrality goals. Additionally, 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.

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<sup>34</sup> 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, available at [https://www.ipcc.ch/site/assets/uploads/2018/02/SYR\\_AR5\\_FINAL\\_full.pdf](https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf).

<sup>35</sup> California Council on Science & Technology (CCST), *California's Energy Future: The View to 2050* (May 2011), available at <https://ccst.us/wp-content/uploads/2011energy.pdf>.

<b>Policy</b>	<b>Description</b>
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

### 7.3.5 Equity Considerations

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.

Additionally, 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).

#### **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.

## 8 GAS OPERATIONS

The Gas Operations Program area supports pipeline transportation and storage operations through innovations that enhance pipeline and employee safety, maintain system reliability, increase operational efficiency, and minimize GHG and operational impacts to the environment. The program also supports 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 Program Benefits

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

<b>Benefit</b>	<b>Explanation</b>
Reliability	Program staff support projects focused on developing methods and technologies for more effective pipeline construction, alteration, and repair, and on minimizing impacts to customers through avoidance of service interruptions and extending the service life of the pipeline infrastructure.
Safety	Projects in this Program area 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 general public, company employees, and contractors working on or around the pipeline and system facilities.
Operational Efficiency	Program staff consider operational efficiency as a driver when identifying and comparing technologies. For example, they seek to identify practices that leverage automation of data gathering and analytics to advance pipeline safety and regulatory compliance.
Improved Affordability	By driving the development of technologies and innovations that reduce operational costs, program staff seek to increase energy affordability for ratepayers.
Environmental: Reduced GHG Emissions	Projects in this Program area develop technologies and best practices for reducing GHG emissions and mitigating the impacts of the gas system on climate change.

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Environmental: Improved Air Quality

Projects in this Program area reduce the environmental impact of the pipeline system and system operations by reducing the emissions of harmful air pollutants, such as post-combustion criteria pollutants.

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### 8.1.1 Equity Considerations

The natural gas pipeline system serves customers regardless of their socioeconomic status. The Gas Operations Program area funds a wide variety of projects applicable to all aspects of system pipeline operations. Many of this program area’s projects improve the efficiency of the gas pipeline and, thus, 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 area are adopted nationally by other utilities, which supports equity across the nation.

## 8.2 Proposed 2022 Gas Operations Funding Allocation



Subprogram	Allocation
Environmental & Safety	\$712,541
Operations Technology	\$534,406
System Design and Materials	\$1,425,081
System Inspection & Monitoring	\$890,676
<b>Total</b>	<b>\$3,562,704</b>

Figure 3: Visual Summary of proposed 2022 Funding Allocations for Subprograms within the Gas Operations Program

## 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.

Further 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 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 the development of technologies or systems aimed at the 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 the development of a diversified portfolio of energy sources.
- **Area 2: Environment**  
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. This effort 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.
- **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 below ground piping systems. Safety projects related to worker safety include those advancing training technologies and knowledge transfer.

### 8.3.3 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	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 emissions from organic waste
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
Cal/OSHA Title 8 CCR	Injury and Illness Prevention Program

## 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 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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) pipe repair technologies, pipeline construction technologies, composite repair wraps, adhesive patches, or polymer encapsulation systems that are easily applied over the damaged section of PE pipe. 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 the 21% of 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 criteria pollutants. Through evaluation and testing of new methane leak detection equipment, this research area supports the SoCalGas goals of decarbonization and diversity of energy.

### 8.4.3 Policy Considerations

Operations Technology projects support these key policies and regulations:

Policy	Description
DOT 49 CFR Part 192	Federal pipeline safety regulations
PUC 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

## 8.5 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 lifecycle 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 non-traditional 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.

### 8.5.2 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 the 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. Additionally, 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 to mitigate risks prior to installation. The 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. Additionally, 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 in order to identify those that can improve the longevity and thus 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 1) a web-based software solution to provide maximum allowable operating pressure and materials verification to operators; 2) an approach to streamline the traceability of steel assets; and 3) a marking standard for pipeline components.

### 8.5.3 Policy Considerations

System Design & Materials projects support key policies and regulations:

Policy	Description
AB 32	Reducing GHG emissions
CPUC General Order 112F	Gas Transmission & Distribution rule
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

## 8.6 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 artificial intelligence (AI), machine learning, and preventive and predictive maintenance technologies, including data analytics 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 2022 Key Research Areas

Based on input received during outreach activities, in 2022, this subprogram will target the following key research areas with funds for projects under development:

- **Area 1: Pipeline Systems Inspection Technologies—Inline and Non-Destructive Examination (NDE)**  
Projects in this area develop sensors using Electromagnetic Acoustic Transducer (EMAT) technologies with sensitivities capable of detecting cracks in the pipe wall and long-seam welds and measuring the remaining wall thickness. Energy harvesting technology is also being demonstrated to recharge onboard inspection robot batteries in-situ without removing the system from the pipeline.
- **Area 2: Remote Pipeline Monitoring Systems**  
Gas Operations personnel are currently evaluating a number 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 the Internet of Things (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, using an advanced fiber-optic system installed along the pipeline right-of-way. This technology can provide continuous real-time measurement of strain imposed onto the pipeline and alert pipeline operators to take mitigative measures to avoid pipeline failures. This research area supports the SoCalGas goal of digitalization.

### 8.6.3 Policy Considerations

System Design & Materials projects support key policies and regulations:

<b>Policy</b>	<b>Description</b>
AB 32	Reducing GHG emissions
CPUC General Order 112F	Gas Transmission & Distribution rule
DOT 49 CFR Part 192	Federal pipeline safety regulations
Clean Air Act	Air quality standards for NOx and PM

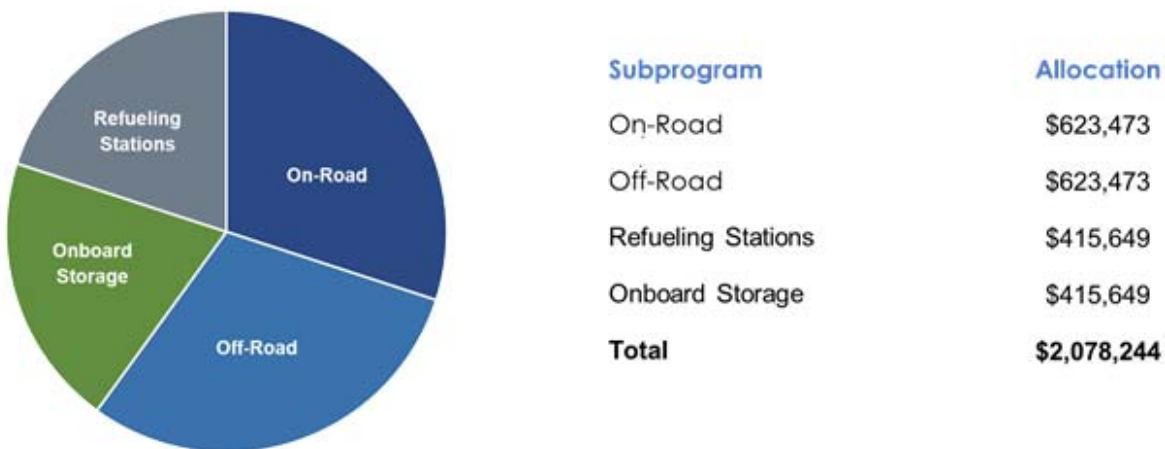
## 9 CLEAN TRANSPORTATION

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 onboard 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 2022 Clean Transportation Funding Allocation



**Figure 4:** Visual Summary of proposed 2022 Funding Allocations for Subprograms within the Clean Transportation Program.

### 9.2 Off-Road

#### 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.

### 9.2.2 Subprogram Benefits

Benefit	Explanation
Reliability	Fuel-cell electric vehicles (FCEVs) could reduce dependence on foreign oil since 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 the California. Zero-emissions vehicles produce no tailpipe NOx or PM emissions.

### 9.2.3 2022 Research Areas

Based on input received during outreach activities, in 2022, 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, wheel dozers, etc., 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 pressure 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.<sup>36</sup> 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 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

#### 9.2.5 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.<sup>37</sup>

### 9.3 On-Road

#### 9.3.1 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.

#### 9.3.2 Subprogram Benefits

Benefit	Explanation
Reliability	FCEVs could reduce U.S. dependence on foreign oil since 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%).

<sup>36</sup> See, e.g., Airlines for America, Airlines Fly Green, - *Committed to Net-Zero Carbon Emissions by 2050*, available at <https://www.airlines.org/airlines-fly-green/>.

<sup>37</sup> California Air Resources Board, *2020 Mobile Source Strategy*, available at <https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy>.

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.

### 9.3.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 FCEVs and zero-emission technologies for MHD freight and people transportation. Projects also demonstrate ZEVs to encourage the 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 the total cost of ownership, techno-economic analyses, planning, and roadmaps towards the adoption of zero-emission vehicles.
- 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.

### 9.3.4 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

### 9.3.5 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 the development of zero-emission clean transit solutions, which typically benefit residents of ESJ communities more than other groups.

## 9.4 Refueling Stations

### 9.4.1 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.

“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

### 9.4.2 Subprogram Benefits

Benefit	Explanation
Reliability	FCEVs could reduce U.S. dependence on foreign oil since 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 can 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 delivering hydrogen to customers.

### 9.4.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 fuel cell electric vehicles (FCEV). This helps alleviate range anxiety and better adoption of gaseous vehicles that significantly reduce emissions versus their liquid fuel counterparts.



- Area 2: Hydrogen Refueling Station Optimization and Safety**  
 While 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 is imperative for the successful adoption of both NGVs and FCEVs. Safety of refueling stations and components is a top priority for the station and vehicle operators of ZEVs.

#### 9.4.4 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

#### 9.4.5 Equity Considerations

Infrastructure is crucial to support the growth of hydrogen mobility. Infrastructure will ensure that the customer has a safe, convenient, reliable, high-quality, low-cost fueling experience.

"Transitioning to a ZEV future will improve public health, reduce transportation costs for Californians, expand economic development and create jobs, and, with the right planning, improve the reliability of the electric grid. At the same time, the state must ensure access to clean mobility options to ensure low-income and disadvantaged communities benefit from this transition."<sup>38</sup>

### 9.5 Onboard Storage

#### 9.5.1 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 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.

#### 9.5.2 Subprogram Benefits

Benefit	Explanation
Reliability	Low-pressure and advanced onboard storage tanks can provide greater cycle life and reduce the required load on infrastructure.
Safety	Advanced materials can help store fuel at lower pressures and meet the highest safety requirements of high-pressure storage vessels.

<sup>38</sup> State of California Energy Commission, *Integrated Energy Policy Report Update Volume I: Blue Skies, Clean Transportation Executive Summary* (2020) at 1, available at [https://www.energy.ca.gov/sites/default/files/2021-03/2020\\_IEPR\\_Update%20Vol%20I%20ExecutiveSummary.pdf](https://www.energy.ca.gov/sites/default/files/2021-03/2020_IEPR_Update%20Vol%20I%20ExecutiveSummary.pdf).

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.

### 9.5.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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.

### 9.5.4 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

### 9.5.5 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.”<sup>39</sup>

<sup>39</sup> Ballard, *Disadvantaged Communities Need Better Public Transport Access, Clean Energy Fuel Cell Electric Buses* (February 22, 2018), available at <https://blog.ballard.com/public-transport-access>.

# 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 in order 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 2022 Clean Generation Funding Allocation

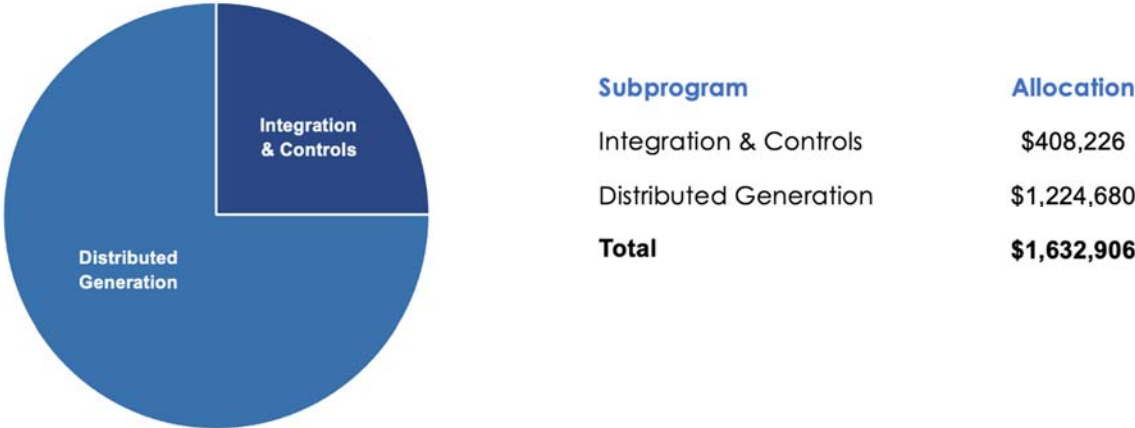


Figure 5: Visual Summary of proposed 2022 Funding Allocations for Subprograms within the Clean Generation Program

## 10.2 Distributed Generation

### 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.

### 10.2.2 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.

### 10.2.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, this subprogram will target the following key research areas with funds for projects under development:

- Area 1: Commercialization of Small Scale (less than 50 kilowatts) 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 are becoming increasingly available in South Korea. There are currently no commercially available small SOFCs in the U.S. 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 Shutoffs (PSPS) events and other grid disturbances, while limiting GHG and criteria pollutant emissions.

### 10.2.4 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 <sub>2</sub> emissions
Clean Air Act	Air quality standards for NO <sub>x</sub> 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

### 10.2.5 Equity Considerations

Low-emission, DG technologies have the ability to 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 LICs improves air quality.

## 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 Subprogram Benefits

Benefit	Explanation
Reliability	Ensuring 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. Also, 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 <sub>2</sub> emissions by providing onsite 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 (NO <sub>x</sub> ) by providing onsite electricity that is cleaner than grid-sourced electricity and potentially offset gas consumption when CHP is optimally utilized.

### 10.3.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 towards 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 CHP systems. Improving the total efficiency of a CHP system by utilizing 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 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), onsite 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

### 10.3.5 Equity Considerations

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

# 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 2022 Customer End-Use Applications Funding Allocation



Figure 6: Visual Summary of proposed 2022 Funding Allocations for Subprograms within the Customer End-Use Applications Program

## 11.2 Commercial Food Service

### 11.2.1 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.

### 11.2.2 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 costs.

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.

### 11.2.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 the adoption of new high-efficiency equipment through technology development, demonstrations, webinars, conference presentations, and journal publications.

### 11.2.4 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 <sub>2</sub> emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

### 11.2.5 Equity Considerations

Half of all American adults have worked in the restaurant industry. This sub-program seeks to reduce emissions, improve air quality, and increase profitability for an important sector that employs more minority workers than any other industry.<sup>40</sup>

<sup>40</sup> National Restaurant Association, *Commitment to Diversity, Equity, and Inclusion*, available at <https://restaurant.org/about/our-industry/commitment-to-diversity-equity-and-inclusion>.



## 11.3 Residential Appliances

### 11.3.1 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, water heaters, stoves, ovens, and dryers.

### 11.3.2 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 costs 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.

### 11.3.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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.

### 11.3.4 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 <sub>2</sub> emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

### 11.3.5 Equity Considerations

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

## 11.4 Commercial Applications

### 11.4.1 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.

### 11.4.2 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 costs 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 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.

### 11.4.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 a particular focus on NOx emissions and energy efficiency. Projects will identify feasible modifications to equipment to accommodate higher blends.

### 11.4.4 Policy Considerations

Commercial Applications projects support key policies and regulations:

<b>Policy</b>	<b>Description</b>
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 <sub>2</sub> emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

#### 11.4.5 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.

### 11.5 Industrial Process Equipment

#### 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.

<b>Benefit</b>	<b>Explanation</b>
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.

#### 11.5.2 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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 the 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 a particular focus on NOx emissions.

### 11.5.3 Policy Considerations

Industrial Process Equipment 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 <sub>2</sub> emissions 40% below 1990 levels by 2030
EO B-55-18	Carbon-neutral California economy by 2045
AB617	DACs for air quality improvements

### 11.5.4 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.

## 11.6 Advanced Innovation

### 11.6.1 Subprogram Overview

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

### 11.6.2 Subprogram Benefits

Benefit	Explanation
Safety	These innovations increase customer safety by monitoring for equipment failures (e.g., 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.

### 11.6.3 2022 Key Research Areas

Based on input received during outreach activities, in 2022, 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, block-chain, 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.

### 11.6.4 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
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 <sub>2</sub> 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

### **11.6.5 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.

## Appendix A: Stakeholder Input

Prior to the workshop in the first quarter of 2021, Momentum, on behalf of SoCalGas, conducted stakeholder outreach interviews with more than 50 individuals from 21 different organizations (Section 3.1). This table lists the questions posed during the interviews and an anonymized summary of responses from the various stakeholders.

Question	Responses
<b>A. What are the key technology gaps that need to be addressed?</b>	<ol style="list-style-type: none"> <li>1. Decarbonization, especially as it relates to hydrogen.</li> <li>2. Use of existing assets for decarbonized energy storage and distribution.</li> <li>3. Technical issues around upgrading biogas to pipeline-quality renewable natural gas (RNG).</li> <li>4. Onboard RNG/hydrogen storage for medium- and heavy-duty (MHD) vehicles and equipment.</li> <li>5. More demonstration projects on MHD vehicles using hydrogen fuel to illustrate advantages of hydrogen over battery technology.</li> <li>6. Hybrid RNG vehicles and equipment.</li> <li>7. Accurate and up-to-date carbon and methane accounting and lifecycle analysis methodologies.</li> <li>8. Technologies for decarbonizing high-heat and high-energy industries.</li> <li>9. Understanding the limitations and barriers to integrating and blending hydrogen into existing pipeline and infrastructure.</li> <li>10. Data management, storage, and collection solutions and the incorporation of artificial intelligence (AI). Includes predictive data analysis tools for better risk management and safety.</li> <li>11. Testing facilities for hydrogen blending in pipeline.</li> <li>12. Larger, multi-organizational projects tackling major challenges, such as decarbonizing entire towns or cities.</li> <li>13. Fuel cell systems for heating water and generating electricity.</li> <li>14. RNG heat pumps.</li> <li>15. Automation and safety devices.</li> <li>16. Better tools for mapping and understanding locations of underground infrastructure.</li> <li>17. Understanding impact of blending hydrogen into pipeline on safety and integrity of system.</li> <li>18. Natural gas with carbon capture for production of zero-emission hydrogen for transportation.</li> <li>19. Onsite emergency generators and self-powered appliances for consumers.</li> <li>20. Testing facilities for subsurface storage of hydrogen and long-term hydrogen energy storage.</li> <li>21. Harnessing the sun's power for hydrogen production.</li> <li>22. Carbon capture for renewable methane.</li> <li>23. Carbon capture and downstream applications for captured carbon.</li> <li>24. Real-world demonstrations of robust technology systems for better understanding of return on investment (ROI).</li> </ol>

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25. Reducing fugitive methane emissions.
  26. Well-to-wheel analysis for hydrogen.
  27. Hydrogen separation technology.
  28. Cost-effective conversion technologies, such as pyrolysis.
  29. Power-to-gas grid-scale storage.
  30. Fuel cell technology for use at dairy farms and associated showcase demonstration sites.
  31. Fuel cell technology for vehicles and infrastructure.
  32. Market surveys.
  33. Open-source software to identify seismic risk to natural gas infrastructure.
  34. Reliable and redundant distributed hydrogen production technology.
  35. Conversion of existing compressed natural gas (CNG) fueling infrastructure to CNG turbine facilities that could support facility loads and charge batteries to be used in zero-emission vehicles (ZEVs), supporting resiliency and continuity of operations.
  36. Integration of microgrids into urban transport systems, where real estate is limited.
  37. How to scale up electrolysis technology.
  38. Hydrogen pilot projects to develop necessary fire code modifications. Includes mobile hydrogen refuelers and close collaboration with fire officials.
  39. Feasibility assessment of a hydrogen tugboat.
  40. Residential applications of micro-combined heat and power (CHP) systems.
  41. End-use appliances and equipment fueled by hydrogen.

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**B. What technical questions are most pressing from a research standpoint?**

1. How could ammonia be used as an alternate energy carrier?
  2. What is the upper limit of a hydrogen blend in the existing pipeline?
  3. How will new technology impact ESJ communities?
  4. What role could mobile hydrogen play in providing backup for the grid during long power outages?
  5. How do we safely integrate hydrogen as a decarbonization tool into the existing infrastructure?
  6. How do you safely put hydrogen in natural gas pipelines and minimize the risk of embrittlement?
  7. Is there a way to safely transport hydrogen in existing pipelines and remove it at its destination cost-effectively?
  8. How can we use data science to optimize the existing natural gas infrastructure system?
  9. How do we detect and quantify methane emissions?
  10. How can we develop a standard system of accounting for methane emissions?
  11. How do we differentiate gas depending on how it has been sourced and transported?
  12. How do we optimize the grid and use the existing infrastructure as a grid storage resilience program?
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13. How are codes and standards impacted by introduction of low-carbon fuel blending?
  14. Will monitoring and detection equipment work correctly at different blend rates?
  15. Even beyond blending, how can we leverage existing infrastructure to support a 100% hydrogen gas supply?
  16. Can we cost-effectively produce hydrogen from natural gas or RNG?
  17. Are entire towns and neighborhoods fueled on hydrogen feasible?
  18. How are gas facilities affected by California fires?
  19. What do we do with all the data produced by our complex web of sensors, light detection and ranging (LiDAR), and continuous monitoring? How do we transport, store, and manage the data?
  20. How do leaks change emissions factors?
  21. There is a movement toward certified gas, responsible gas. How do we measure that?
  22. What is the maximum acceptable blend of hydrogen in the pipeline?
  23. How do 5%, 10%, and 15% hydrogen blends work in the pipeline?
  24. How could we leverage our existing infrastructure in a 100% hydrogen scenario? We need to look at this now so we are ready in 10 years. Can we convert the existing pipelines to 100% hydrogen or will major modifications be required?
  25. What can we learn now to avoid future cost increases associated with a blended pipeline?
  26. As natural gas consumption drops, what will the gas company do to ensure that ratepayer costs do not skyrocket?
  27. How can we use the existing pipeline to explore hydrogen blending, separation, and compression?
  28. How can we decarbonize high-energy industries, such as cement making? What role will RNG and hydrogen play?
  29. How do we produce and distribute green hydrogen for transportation?
  30. How do we reduce the total cost of ownership (TCO) of hydrogen so it can better compete in market?
  31. How can we use hydrogen for energy storage and resilience?
  32. What role should near-zero-emission technology play in the energy transition? Is it a bridge technology or does it have a place in the future?
  33. What do we do with existing assets and suppliers?
  34. What pathways for specific industry sectors make sense for hydrogen?
  35. How can we lower the cost of producing hydrogen and RNG?
  36. How do we lower the TCO of hydrogen and RNG trucks so they better compete in the market?
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37. How can hospitals and other healthcare facilities use green hydrogen and RNG, while still complying with stringent outside air and safety requirements?
  38. Can we generate clean electricity for our fleet using RNG?
  39. Does a viable business model exist for hydrogen fuel cell transit buses?
  40. How can we adapt new technologies so that they fit into the existing boundaries of urban transit facilities, which are often space constrained?
  41. People rely on our buses. How can we obtain backup generation if we go all-electric?
  42. How can we future-proof heating, ventilation, and air conditioning (HVAC) systems against the movement toward building electrification?
  43. How can we produce green hydrogen in sufficient quantities to fuel drayage trucks? Where would all that hydrogen come from?
  44. How can we get a hydrogen truck that meets or exceeds the performance of a diesel truck? How will it handle heavy work?
  45. How can we refuel hydrogen trucks in 20 minutes or less?
  46. How will the business model change with the transition to hydrogen in the pipeline? How would current practices change with a blended pipeline?
  47. How can we improve risk assessment?
  48. How can we really understand the extent of leaks and how to fix the efficiently?
  49. What are the long-term effects of hydrogen blends on steel pipelines, valves, gaskets, etc.?
  50. Is pyrolysis/gasification able to convert biomass to fuels at appropriate scales?
  51. If we assume there will be a hydrogen economy, is it cheaper and faster to get there with a large-scale utility approach or distributed generation?
  52. Where does CCS comes in to play, especially in regard to dealing with emissions from power plants?
  53. What will the energy company look like in 25 years? What can we do now to move us in that direction? How can we test our progress toward those goals in 10 years?

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**C. What pain points must be addressed for natural gas customers?**

1. Price and the need to keep energy affordable and equitable.
  2. Reliability of electricity grid. Can we use the natural gas grid as backup or in parallel to deliver energy?
  3. Carbon monoxide threats.
  4. There is a lot of desire for RNG but not a tremendous amount of volume or availability.
  5. Uncertainty about local municipalities and permitting requirements for RNG.
  6. Potential cost increases associated with pipeline decarbonization.
  7. Higher costs associated with ZEVs.
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8. Gas companies have not done a good job of explaining themselves to customers. Customers do not understand the true cost of producing energy and delivering it to homes and businesses. If we electrify too fast, energy bills will rise too fast and high.
  9. Customers don't like the GHG emissions associated with natural gas.

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**D. What are the top three research priorities?**

1. Low carbon resources.
2. Energy resilience (providing reliable energy including grid integration and how electricity and gas interact).
3. Energy equity and how to deliver affordable, clean energy to all communities.
4. Fuel reforming from natural gas to hydrogen.
5. Data processing, IoT, modeling, AI.
6. Methane emissions within entire value chain, from distribution to end-use.
7. Cost-effective RNG solutions.
8. Emissions and leak detection technology development. Can a safe transition to a low- or no-carbon future be accomplished with the same or better level of safety as today?
9. Climate change/decarbonization.
10. Reducing NOx emissions through the use of hydrogen in the pipeline.
11. Energy affordability.
12. Demonstrating the long-term system stability and viability of new energy systems.
13. How to scale up new technologies in a steady, incremental fashion.
14. Industrial process heating technology.
15. Energy resilience and redundancy as we move away from diesel, with its many suppliers.
16. Zero-emission off-road gear for cargo handling.
17. Mobile refueling of off-road equipment.
18. Cleaner harbor craft.
19. Understanding impact of hydrogen on steel pipelines.
20. Residential gas-fired heat pump technology.
21. Methane pyrolysis for decarbonization.
22. Carbon capture and utilization to turn carbon into an asset.

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**E. Are we funding anything that does not merit funding?**

1. All seems very relevant.
2. 10% for administrative costs seems high.
3. Advanced innovation section.

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**F. What agencies present significant areas of collaboration?**

1. More collaboration with international companies that are further along in decarbonizing would be valuable.
  2. California Energy Commission programs can be complementary and not duplicative because the pie is enormous.
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**G. What gaps exist in agency funding where the RD&D Program could supplement the work of other programs?**

1. Underground hydrogen storage.
2. Scale of projects seems too small and not as imaginative as projects in Europe. There is a lack of large, bold projects.
3. Technology to use in training the workforce of tomorrow and training and qualifying operators.
4. How to scale hydrogen generation.
5. Accurate, up-to-date well-to-wheel analysis comparing EVs and fuel cells.
6. Carbon capture.
7. Safety is underfunded.
8. Developing monitoring technology for storage wells.
9. U.S. Department of Energy's Bioenergy Technologies Office doesn't do a lot of work with end-user in terms of testing and evaluating. Important to fund collaborations and build supply chain off-takes.
10. Need more research into the long-term commercialization and scaling of new technologies, particularly around helping manufacturers produce at sustainable rates.
11. Zero-emission harbor craft.

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**H. Can you recommend other ways that we could share information about our work?**

1. Regular newsletters.
  2. Social media.
  3. Engagement with broad set of stakeholders, including regulatory bodies, environmental non-profits, and financial institutions.
  4. Project videos.
  5. Student design projects with winner(s) receiving job interview(s).
  6. Presentations and booths at industry events and conferences.
  7. Regular research webinars on key topics and successful projects.
  8. White papers.
  9. Trade publications.
  10. Articles for general media.
  11. Need to communicate the results of your projects and program regularly and share it widely. Justify your program by discussing emissions benefits.
  12. Piggyback on existing events or newsletters, where your audience is already convening.
  13. Create an online clearinghouse to educate public and research community.
  14. Quarterly program area updates.
  15. A website that better highlights program and project success, increases the profile of the RD&D program, and demonstrates good fiscal stewardship and ratepayer benefits.
  16. Taking part in panel discussions.
  17. Update key contacts in major agencies quarterly on program progress.
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18. Publish publicly available project reports to help other researchers understand what has been done. The easier to digest, the better.
  19. Library of white papers and one-pagers.
  20. Target educational material at policy makers, who come and go. It's an ongoing campaign.

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**I. Can you suggest any ways we could have a greater impact on underserved communities or ways we can increase diversity and inclusion within the research program?**

1. Grow equity from a review criterion to its own research program. Equity should not be an afterthought; it requires and deserves a deep dive to understand the impacts.
2. Pilots and field-testing demonstrations that work directly with disadvantaged communities (DACs) and in underrepresented areas.
3. Connect pilot projects with local schools for an education and workforce/career component. Education is vital to improving equity. It gives students the power to change their lives.
4. Interact with thought leaders in these communities.
5. Collaborate with ESJ groups in demonstration projects.
6. Collaborate with underserved academic institutions.
7. Focus on eliminating emissions from MHD trucking.
8. Strategically locate refueling stations to ensure energy equity.
9. Use CalEnviroScreen as a tool when deciding which projects to fund and where to perform workforce development.
10. Hold regular meetings focused on how RD&D Program projects can positively impact ESJ communities.
11. Conduct demonstration projects in ports, which are often surrounded by ESJ communities.
12. Conduct RD&D work on public transit or alternative forms of transportation that don't require single vehicle riders.
13. Ensure that key communication and development materials accommodate ESJ communities.
14. Develop messaging around translating the science into benefits to ESJ communities.
15. Seek regular input from ESJ community members.
16. RD&D work is unrelated to cultural, racial, or gender issues and should be judged on its technical and scientific merits.
17. Address the affordability of new end-use applications.
18. Work with local stakeholders to ensure that the problems you are trying to solve are important to them. It is very important to build trust.

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**J. What is your overall assessment of the SoCalGas RD&D Program?**

1. It seems to be pretty specific and pretty deep. "That's the way to go—deep."
  2. You are not going to solve everything. It is important to prioritize.
  3. SoCalGas leads the way in RD&D and innovations, both in emerging technologies and deployment. The company is aggressive when it comes to decarbonization and implementing clean technology.
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4. Other utilities and regulatory agencies see SoCalGas as ahead of the curve and leading the way.
  5. It's a pretty strong program, especially relative to other utilities.
  6. The program is unknown. I have taken funds from SoCalGas but didn't realize there was an actual program backing that. The program seems to be hidden.
  7. There is not enough marketing of the program itself. You need to market the program partly to rehabilitate the company and to get the word out that you're working on all this beneficial stuff.
  8. You need to spend more money.
  9. Very impressed that SoCalGas is exploring the use of hydrogen for transportation.
  10. The program is too unknown, hidden. Who are the contact people? How do we apply for funds?
  11. SoCalGas is viewed in a leadership role amongst utilities.
  12. The program's R&D priorities are spot on.
  13. "Pretty comprehensive."
  14. The program leads the way with being innovative and aggressive in pursuing decarbonization and implementing technology.
  15. Leading the way among utilities.
  16. "Very positive."
  17. That it's good, but don't know what the details are.
  18. They put their money where their mouth is.
  19. Commendable. They share lessons learned with other utilities.
  20. I give them high marks. A model partner.
  21. SoCalGas does R&D at a meaningful scale.
  22. The program sets an example for other utilities by taking risks on technologies and being willing to be a first mover.
  23. Other utilities will benefit from the risks that SoCalGas is taking on innovative technology. I would love to see this level of leadership in other areas.
  24. Funds research that is complementary. We have been good partners with SoCalGas. Their ability to match us enables us to fund larger projects.
  25. I am excited about SoCalGas' work in low carbon resources. My impression is positive but I wasn't previously familiar with all of the things that have been going on in the program. It looks comprehensive.
  26. More nimble than state programs. Can make decisions fast.
  27. "It's critical that this research funding continue because that is how we are going to get further efficiencies for environmental performance and that's how we get to a place where all stakeholders are happy and satisfied with the process."
  28. Impressed with their ambitions in hydrogen. Great program. Complements our program well. I want to continue working together. Keep up your work with biogas to renewable fuels.
  29. "No idea what the RD&D Program is about."
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	<ul style="list-style-type: none"> <li>30. SoCalGas taking leadership to develop technology and implement it is important.</li> <li>31. Very high regard for the program. SoCalGas champions a lot of good work in our industry.</li> <li>32. The RD&amp;D Program is one of the most effective RD&amp;D organizations. It is hampered a little by all of the required reporting.</li> <li>33. Vaguely knew of the program and that it is driven by regulations. From the nominal amount I've seen, it's a good effort and I would like to learn more about how to leverage what the program is doing.</li> <li>34. Visited the SoCalGas research labs in Los Angeles and was jealous.</li> </ul>
<b>K. How does it differ from other R&amp;D programs?</b>	<ul style="list-style-type: none"> <li>1. The fact that it exists is a differentiator. It is vastly superior to any other utility program in the U.S. and Canada. It is unique and should be commended. There is less than a handful of real R&amp;D programs to point to that show the kind of content and forethought that this one does.</li> <li>2. More focused and more applied. Proactive instead of reactive. Likes to get ahead of issues.</li> <li>3. Utility funding has more flexibility than government funding.</li> <li>4. SoCalGas can identify a problem and solve a problem for a particular market segment. It is more nimble than the state and has more control over how projects happen.</li> <li>5. There is no liquidation issue. Contracts and invoicing are streamlined. This is a huge benefit.</li> <li>6. Flexible. Smoother deployment of funds where they need to go.</li> <li>7. The RD&amp;D Program is a very well-organized entity. Staff is well educated and at the top of their game.</li> <li>8. Broad coverage of many topics, rather than narrow scope like many agencies tend to do.</li> </ul>
<b>L. What customer segment (residential/commercial/industrial) needs additional support from RD&amp;D?</b>	<ul style="list-style-type: none"> <li>1. Industrial decarbonization.</li> <li>2. On the building side, gas heat pump technology.</li> <li>3. Industrial and high heat generation needs. This is one of the hardest areas to decarbonize.</li> <li>4. Transportation sector for the most immediate impact.</li> <li>5. Resiliency.</li> <li>6. Residential.</li> </ul>
<b>M. What else should SoCalGas consider doing to strengthen its RD&amp;D program?</b>	<ul style="list-style-type: none"> <li>1. Strengthen overlap and collaboration potential.</li> <li>2. Leverage university relationships.</li> <li>3. Identify specific opportunities within federal and state agencies to leverage their R&amp;D dollars further.</li> <li>4. Marketing is important. It is difficult to find out about RD&amp;D Program projects and programs. The program needs more visibility to promote technologies and how money is being</li> </ul>

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- spent. Should be spending more money. Could create a fund pool with another organization.
5. Incorporate workforce development and long-term educational pathways. Educate young people and leverage their enthusiasm and faculty involvement.
  6. Develop courses or programs to develop the workforce of the hydrogen future. If you want to change, you need to educate students.
  7. Need to fund larger demonstration projects. And to make them visible! Use your clout to do bigger projects. Need a moonshot program. Look at ports, sea and air.
  8. Increase funding. \$16M is not enough.
  9. More visibility and transparency.
  10. Would like to see larger demonstrations and a positive message for ratepayers about your work.
  11. More national and international collaboration.
  12. Make it clear that the program is emissions driven.
  13. Use a monthly newsletter to keep people informed about the program and your projects.
  14. Provide an easy-to-digest quarterly one-pager for each program area.
  15. Embed your program more deeply into the R&D ecosystem.
  16. Consider whether or not the program is spread too thin. It would be valuable to do some self-assessment to determine if you could have more impact by narrowing its scope.
  17. Are you trying to do too much? Would you be more effective doing fewer projects better?
  18. Do a better job of keeping stakeholders informed about what you're doing.
  19. Distribute regular updates on new research, results, and feasibility. This is very important.
  20. Strengthen outreach campaigns.
  21. Focus on communicating what SoCalGas is funding, what it's achieved to date.
  22. Increase public outreach. Better communicate what you're doing and what you've accomplished.
  23. Collaborate with other utilities to ensure the program is not duplicating what is happening in other markets.
  24. Invest where it makes the most sense. If California customers will benefit from something happening in Nebraska, fund it.
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## Appendix B: Public Workshop Questions & Comments

Name	Questions & Comments
Noe Contreras (Northwest Energy Efficiency Alliance)	<p><b>Q1:</b> The Northwest Energy Efficiency Alliance would like to collaborate further. How do we take the first steps?</p> <p><b>A:</b> The SoCalGas RD&amp;D Program collaborated with NEEA on two projects in 2020. We look forward to continuing our work together and will connect you with our Customer End-Use Applications RD&amp;D Program team. The two projects were:</p> <ul style="list-style-type: none"><li>• GTI Residential Gas Heat Pump Water Heater North America Field Demo (2020 Annual Report, Page 212)</li><li>• Rinnai Residential GHPWH Product Development and Testing (2020 Annual Report, Page 214)</li></ul>
Brandon Iglesias (Reactwell)	<p><b>Q2:</b> What projects are planned for 2022 to address grid-scale energy storage on MWe-hr [megawatt-hour electric] days?</p> <p><b>A:</b> SoCalGas is pursuing a few different approaches. The first consists of studies conducted in collaboration with UC Irvine to better understand:</p> <ul style="list-style-type: none"><li>• How the existing natural gas grid can be leveraged for long-duration storage of renewable hydrogen generated from curtailed/surplus electricity; and</li><li>• How the natural gas grid can be transformed, and at what cost, to accommodate large amounts of renewable hydrogen.</li></ul> <p>The second consists of exploring and demonstrating low-cost and scalable power-to-gas methanation processes where renewable hydrogen and recycled carbon dioxide emissions are combined to generate renewable natural gas [RNG]). This is a very attractive pathway for megawatt-electrical-hour storage because it is rapidly scalable and does not suffer from the physical or mechanical limitations of the gas grid system and end-users for storing and utilizing pure or blended hydrogen. One of our partners, Electrochaea, just announced plans to build a 10-megawatt biological methanation system.<sup>41</sup></p> <p>Finally, low-cost and grid-scale renewable hydrogen production using photoelectrochemical (sun-driven direct water-splitting) and advanced electrolysis pathways is also being evaluated. We are working with Caltech and H2U technologies on these two pathways, respectively. However, these technologies have a lower technology readiness level (TRL) than methanation processes and are not quite ready for large-scale deployment.<sup>42</sup></p>

<sup>41</sup> Electrochaea, *Electrochaea and the European Innovation Council Accelerate Rollout of Biological Methanation Technology*, available at [https://www.electrochaea.com/wp-content/uploads/2021/04/20210415\\_PM\\_Electroc\\_\\_Council\\_EN\\_fin.pdf](https://www.electrochaea.com/wp-content/uploads/2021/04/20210415_PM_Electroc__Council_EN_fin.pdf).

<sup>42</sup> PRNewswire, *SoCalGas and H2U Technologies Partner to Test New Technology that May Make Green Hydrogen at Dramatically Lower Cost* (April 20, 2021), available at <https://www.prnewswire.com/news-releases/socalgas-and-h2u-technologies-partner-to-test-new-technology-that-may-make-green-hydrogen-at-dramatically-lower-cost-301272971.html>.

Name	Questions & Comments
Glenn Bailey (Los Angeles Neighborhood Council Coalition)	<p><b>Q3:</b> For community engagement sessions focused on educational institutions, do you have lists already?</p> <p><b>A:</b> We continue to reach out to educational institutions for additional input. We welcome any suggestions for institutions to connect with, especially if you are able to identify individual contacts.</p>
Judith Ikle (CPUC)	<p><b>Q4:</b> Your video implied 5% biogas. That is potential only correct?</p> <p><b>A:</b> SoCalGas' goal is to provide 5% renewable natural gas to our core customers (<i>e.g.</i>, residential, transportation, small commercial, and industrial) by 2022. SoCalGas is on target to meet that goal.</p> <p><b>Q5:</b> Is SoCalGas open to working with international startups? If yes, what are the requirements?</p>
Wade Bitaraf (Plug and Play Tech Center)	<p><b>A:</b> The RD&amp;D Program team is open to working with international startups, particularly if there is an opportunity to bring new technologies to the California market. Please share any suggestions with us through <a href="mailto:RDDinfo@socalgas.com">RDDinfo@socalgas.com</a>.</p>
Norman Pederson (Hanna and Morton, LLP)	<p><b>Q6:</b> How did you determine the 20% maximum for hydrogen in pipelines? I understand that UC Riverside has a grant to study that issue, and that SoCalGas has proposed a demonstration project on the issue.</p> <p><b>A:</b> SoCalGas RD&amp;D would like to take this opportunity to clarify that the goal presented during the workshop is 20% RNG by 2030, not 20% hydrogen by 2030. The pipeline hydrogen blend limit remains an open question. There are a number of research projects underway across the U.S. to determine what the maximum allowable hydrogen blend percentage would be. SoCalGas RD&amp;D currently has several ongoing research projects on the impact of blending hydrogen with natural gas: Hydrogen Embrittlement and Crack Growth Studies (Phase 1A, 1B, 2A); Hydrogen Impact on Metallic Materials (OTD 6.14.B.2); Impact of Hydrogen/Natural Gas Blends on LDC Infrastructure Integrity (NYSEARCH M2020-002); and Blending Modeling (hydrogen). Please refer to the 2020 RD&amp;D Annual Report for more information.</p>
Jamie Ormond (CPUC)	<p><b>Q7:</b> What type of feedback are you hearing at your community engagement meetings?</p> <p><b>A:</b> The key concerns identified in our community outreach sessions include energy affordability and reliability, particularly with respect to medical baseline patients or patients that are at risk during long power outages. There is also interest from the community in learning more about the technologies that the RD&amp;D Program is bringing to market and helping to develop. We have taken that input into consideration in improving our communications to the community.</p>
Robert Cruz (SoCalGas)	<p><b>Q8:</b> I know you are scheduling a webinar with colleges and higher ed. What about local K-12 districts?</p> <p><b>A:</b> Part of the RD&amp;D Program mandate is to produce high-quality research. As a result, we typically focus our engagement on researchers at the university level. For K-12, we would appreciate input on what sort of engagement would be valuable. Should we focus on collecting feedback and input from K-12 educators? Or K-12 students? Is it more appropriate to focus on education and outreach and sharing the work that we do with K-12 students? Please submit your suggestions through <a href="mailto:RDDinfo@socalgas.com">RDDinfo@socalgas.com</a>.</p>

Name	Questions & Comments
Jamie Ormond (CPUC)	<p><b>Q9:</b> What's the reception like when you discuss hydrogen at community meetings? Is there a variety of knowledge? What do you focus on?</p> <p><b>A:</b> The community outreach sessions are primarily focused on listening and learning about the concerns of the community. Hydrogen is covered briefly as part of the RD&amp;D program and tends to generate lot of interest from stakeholders. They're excited about it as another clean energy option. It is clear that there is some awareness within the communities that hydrogen is an option for decarbonizing transportation and building energy.</p>
Caitlyn Ong (Sempra Energy)	<p><b>Q10:</b> What are we doing, or are we doing anything, to help the low -income areas that may choose cheaper carbon-emitting energy options versus more expensive clean energy options? Do we have low-income customers in mind in our RD&amp;D programs?</p> <p><b>A:</b> Within RD&amp;D, one of the key benefits we look at when analyzing projects and technologies is affordability. Based on the feedback we are receiving at our community outreach sessions, it is clear how important affordability is to the members of our community.</p>
Kieran Mitchell (Scaled Power, Inc.)	<p><b>Q11:</b> Are you aware of the DOE BETO funding opportunity for RNG, which includes \$61.5 million for the full program. Who at SoCalGas might be interested in a biomass/municipal waste to low-cost RNG project?</p> <p><b>A:</b> The RD&amp;D program is interested in biomass conversion to low-cost RNG if there is a new technological improvement proposed that can reduce cost and/or enhance production. Research in this area would fall under the Low Carbon Resources RD&amp;D Program.</p>
Glenn Bailey (Northridge East Neighborhood Council)	<p><b>Q12:</b> Who are the target audiences of your fourth and fifth outreach sessions?</p> <p><b>A:</b> Sessions 3 and 4 will target educational institutions, including universities, California Community Colleges, California State Universities, and University of California local campuses. Session 5 has not been planned at this time. We will incorporate feedback to help guide the design of that session.</p>

Name	Questions & Comments
Jack Chang (CPUC)	<p><b>Q13:</b> How early do stakeholder comments get incorporated into the R&amp;D planning process? Are stakeholders involved in setting high-level R&amp;D priorities? Are stakeholders engaged in translating those priorities into specific projects and deciding where R&amp;D is located?</p> <p><b>A:</b> Stakeholder input is critical to the RD&amp;D planning process, both to develop RD&amp;D priorities and to develop and refine individual project concepts. We gather input through a number of channels:</p> <ul style="list-style-type: none"> <li>• Stakeholder outreach interviews—in 2021, we interviewed more than 50 individuals from 21 different organizations.</li> <li>• Our Annual Stakeholder Workshop.</li> <li>• Community Outreach Sessions as part of the RD&amp;D Equity Engagement Program.</li> <li>• RD&amp;D Research Webinars.</li> <li>• Interaction with other utilities and researchers through our consortium engagements.</li> <li>• At workshops and conferences, such as the CEC’s Natural Gas R&amp;D Annual Workshop, the Fuel Cell Seminar &amp; Energy Exposition, the ARPA-E Energy Innovation Summit, the Pipeline and Hazardous Materials Safety Administrations' Pipeline R&amp;D Forum, the Air Quality Management Plan Working Group, and the American Council for an Energy-Efficient Economy's Hot Water Forum.</li> <li>• Regular interactions with our customers through groups like regional public affairs and our account managers and the teams that operate our system.</li> </ul>
Paul Sandsted (Natural Gas Vehicles for America)	<p><b>Q14:</b> If RD&amp;D priorities were already discussed, can you help me to understand the rationale behind the termination of near-zero-emissions technology projects, especially when they offer the fastest path to reducing heavy-duty vehicle emissions today?</p> <p><b>A:</b> The California Public Utilities Code Section 740.1 provides for the CPUC to authorize utility RD&amp;D activities that benefit ratepayers through improved reliability, safety, environmental benefits, or operational efficiencies provided that achieving those benefits is reasonably probable and the focus is not unnecessarily duplicative of efforts by other research organizations.</p> <p>On March 19, 2021, the Energy Division issued Resolution G-3573 which states: "This Resolution does not approve SoCalGas to spend ratepayer funds on research into Near-Zero Emission CNG Engine Development. This Resolution further restricts SoCalGas to spending ratepayer funds on research into zero-emission vehicle demonstrations, zero emission technology for rail, and zero emission Tier 4 engine research for new construction equipment."</p> <p>Resolution G-3573 can be viewed here:  <a href="https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M372/K329/372329202.PDF">https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M372/K329/372329202.PDF</a></p>
Glenn Bailey (Northridge East Neighborhood Council)	<p><b>Q15:</b> For the City of Los Angeles, please consider outreach to its 99 Neighborhood Councils via one or more of the NC Alliances, such as the NC Sustainability Alliance and/or the LA NC Coalition (<a href="mailto:LANCC@EmpowerLA.org">LANCC@EmpowerLA.org</a>). Thanks.</p> <p><b>A:</b> Thank you for the suggestion. We will consider reaching out this group for a future community outreach session.</p>

Name	Questions & Comments
Judith Ikle (CPUC)	<p><b>Q16:</b> What about schools near gas and oil infrastructure? They are probably interested in learning about the transition from fossil fuels. The minimum set back rule failure has raised interest in fossil fuels' impacts on communities.</p> <p><b>A:</b> We will take this into consideration for future community outreach efforts.</p>
Robert Cruz (SoCalGas)	<p><b>Q17:</b> Please keep K-12 in mind as future audiences to inform and educate in your innovative efforts. Thank you!</p> <p><b>A:</b> We will take this into consideration for future community outreach efforts.</p>
Jeffrey Reed (UC Irvine)	<p><b>Q18:</b> This is a comment on the question of outreach to K-12. SoCalGas conducts substantial outreach to K-12 to encourage engagement in STEM education but much is coordinated through community affairs and involves staff throughout the organization, not just RD&amp;D.</p> <p><b>A:</b> We are working to coordinate more with other groups within SoCalGas, including community affairs and regional public affairs, so that we can leverage pre-existing outreach channels to engage with the community more effectively.</p>

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#### LOW CARBON RESOURCES

Noe Contreras (Northwest Energy Efficiency Alliance)	<p><b>Q19:</b> What are some of the drivers you see that will lower the cost of green hydrogen?</p> <p><b>A:</b> Green hydrogen production cost reduction needs to be approached from both operating and capital cost standpoints. To reduce operating costs, new rules and cost structure need to be established between electric utilities and hydrogen developers (most likely facilitated by the CPUC) to allow hydrogen developers to tap into a very cheap electric power supply, typically curtailed/surplus power, without paying expensive Transmission and Distribution (T&amp;D) charges. Hydrogen developers can now enter into long term Power Purchase Agreements (PPA) with solar farm owners but transmitting this electricity to where it is needed without paying excessive fees for T&amp;D is key. To reduce capital cost, research needs to focus on the development of cheaper and more earth-abundant electrolysis catalysts, as well as the ability to utilize more than just demineralized water, which currently increases the overall system cost.</p>
Norman Pedersen (Hanna and Morton, LLP)	<p><b>Q20:</b> How does methane pyrolysis differ from steam methane reforming?</p> <p><b>A:</b> Methane pyrolysis is the process of dissociating the methane molecule into hydrogen and pure solid carbon, which can have a variety of uses. Methane pyrolysis does not emit any carbon dioxide.</p> <p>Steam methane reforming is the process of blending methane and steam together, in the presence of a catalyst, to re-organize the molecules into hydrogen and other components, including carbon dioxide. Using RNG for the steam methane reforming process produces hydrogen that qualifies as renewable under California's Low Carbon Fuel Standard (LCFS) rules in part because we're preventing the release of biogenic methane, which is a much more potent greenhouse gas than carbon dioxide.</p>

Name	Questions & Comments
David Teichroeb (Triple E Energy Advisors)	<p><b>Q21:</b> Does SoCalGas identify the TRL of the various projects (e.g., starting TRL and expected TRL after project)?</p> <p><b>A:</b> The TRL of a project is identified early on as of part of the initial evaluation of a project’s commercialization potential. The scope of work, including project tasks and deliverables, must demonstrate how the proposed work would help advance the TRL of the technology and bring it closer to commercialization. Specific activities that may help advance the TRL include technology proof of concept, techno-economic analysis (TEA), lifecycle analysis (LCA), and laboratory and field-test demonstrations.</p> <p>At the conclusion of a project, the final deliverables should indicate how the project’s results compared with what was initially proposed and whether the researchers successfully achieved the proposed targets. If the results are widely different than anticipated, a root-cause analysis is performed and subsequent follow-up work to address those issues can be proposed.</p>
Jack Chang (CPUC)	<p><b>Q22:</b> Many of the renewable gas research areas listed on slide 56 are in the 2021 research plan. What additional research topics do you foresee in subsequent plans having to do with hydrogen and renewable gas production?</p> <p><b>A:</b> The current research topics proposed cover a broad range of technologies. We are certainly open to suggestions if someone feels that there is an important technology related to renewable gas production that is being overlooked and not mentioned. From the current list of research topics, there has been an increased interest from our stakeholders in researching advanced water-splitting technologies to bring down renewable hydrogen production cost, as well as demonstrating renewable methane production from methanation pathways, particularly biological methanation, at the MW-scale.</p>
Ahra Kwon (NYSEARCH)	<p><b>Q23:</b> How and when does SoCal Gas educate the gas customer on the benefits and challenges of carbon capture? Seems like public interest is there but timing may be too soon until results are validated.</p> <p><b>A:</b> While there is a tremendous opportunity to leverage carbon capture technologies in the fight against climate change and relatively large-scale facilities have been built worldwide, this technology is still mostly nascent. We are optimistic that over the next three to five years the existing manufacturing bottlenecks will be resolved, carbon capture cost targets will be reached, and a sizeable demonstration facility will be built in southern California. Once that occurs, there will be an opportunity to educate the public regarding the benefits and potential of carbon capture technology. It will be easier to explain the technology once it can be observed in action.</p>

Name	Questions & Comments
Deanna Haines (SoCalGas)	<p><b>Q24:</b> Israel recently announced a solar cell technology that can create enough energy to electrolyze water in a solar panel.<sup>43, 44</sup> Are we looking at this technology also so a separate electrolyzer is not needed?</p> <p><b>A:</b> We are certainly looking at this approach and advancing research into direct water-splitting driven by solar energy, also called photoelectrochemical (PEC) hydrogen production. This research would fall under "Renewable hydrogen production via advanced water-splitting." We are actively working with Caltech on a project to scale-up their state-of-the-art PEC system to 1m<sup>2</sup> with world-record hydrogen production efficiency.</p>
Claire Becker-Castle (SoCalGas)	<p><b>Q25:</b> How are net carbon emissions determined? Can you have negative and positive carbon emissions resulting in net zero carbon emissions? Do RNG and hydrogen production result in negative carbon emissions?</p> <p><b>A:</b> Yes, you can have negative and positive emissions canceling each other out resulting in net-zero carbon emissions. For example, solar panels can work in tandem with natural gas-powered stoves and water heaters to result in net-zero emissions homes. When talking about carbon emissions in the context of RNG and hydrogen, a useful metric is the carbon intensity (CI), which depends not only on the source of the gas but also how it is produced. Using RNG and hydrogen could result in negative emissions when accounting for displaced fossil-sourced gas and avoided emissions which would have resulted from conventional gas utilization.</p>
Wayne Miller (UC Riverside)	<p><b>Q26:</b> Europe has wind-to-hydrogen, which is blended into gas lines. Are you following?</p> <p><b>A:</b> We are certainly following what Europe is doing relative to hydrogen generation from wind (power-to-gas) and blending into the gas lines. In California, our most abundant renewable resource is solar. We have submitted applications to the CPUC to allow hydrogen injection in isolated communities as an initial step for further testing before launching broader injection initiatives.<sup>45</sup></p>
Jack Chang (CPUC)	<p><b>Q27:</b> What is the feasibility of using RNG in methanation and SMR processes?</p> <p><b>A:</b> Methanation is the process through which carbon dioxide and hydrogen are combined to form methane. Methanation is essentially the steam methane reforming (SMR) process in reverse. Whereas SMR generates carbon dioxide and hydrogen from methane and steam feedstock, methanation, as the name implies, generates methane and water from carbon dioxide and hydrogen feedstock. Regarding the SMR processes currently under evaluation, only RNG is being utilized as feedstock to the system to generate renewable hydrogen meeting LCFS criteria.</p>

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## CLEAN TRANSPORTATION

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<sup>43</sup> Hydrogen Digest, *First solar-based process revealed to safely, efficiently split water* (January 8, 2020), available at <https://www.biofuelsdigest.com/hydrogen/2020/01/08/first-solar-based-process-revealed-to-safely-efficiently-split-water/>.

<sup>44</sup> Joule, *Decoupled Photoelectrochemical Water Splitting System for Centralized Hydrogen Production* (February 19, 2020), available at [https://www.cell.com/joule/pdfExtended/S2542-4351\(19\)30591-4](https://www.cell.com/joule/pdfExtended/S2542-4351(19)30591-4).

<sup>45</sup> Application 20-11-004, *Application of Southern California Gas Company, San Diego Gas & Electric Company, Pacific Gas And Electric Company, and Southwest Gas Corporation Regarding Hydrogen-Related Additions or Revisions To The Standard Renewable Gas Interconnection Tariff* (November 20, 2020).

Name	Questions & Comments
Claire Becker-Castle (SoCalGas)	<p><b>Q28:</b> Does any SoCalGas proposed research look at technology issues associated with repurposing existing CNG stations as hydrogen stations?</p> <p><b>A:</b> We have a proposal and projects set in place to address that issue because there's a lot of synergy between compressed natural gas (CNG) stations and hydrogen stations because they both utilize compressed gases. So yes, we are looking at researching that area.</p>
Jack Chang (CPUC)	<p><b>Q29:</b> What is the feasibility of using RNG in CNG transportation applications? What are potential obstacles? Are there still supply issues?</p> <p><b>A:</b> There really aren't any obstacles. RNG is compressed natural gas, a conventional gas, created using feedstock or biogas. As a result, there are actually a lot of greenhouse gas (GHG) benefits when using RNG. Thanks to the LCFS Program, the vast majority of CNG used for transportation applications in California is RNG right now. Likewise, there are no significant supply issues for the transportation industry. All of clean energy in SoCalGas public stations is 100% RNG.</p>
Thomas Harris (Reactwell)	<p><b>Q30:</b> How is that RNG produced? What is the process?</p> <p><b>A:</b> RNG can be produced through a number of pathways, including anaerobic digestion, wastewater treatment plants, and landfill gas. The Low Carbon Resources program area also explores more advanced pathways for producing RNG from biomass feedstocks, or even renewable electricity. If you want to understand all of the pathways around RNG, we recommend looking at CARB's LCFS approved pathways to see all of the different processes that qualify for LCFS credits.</p>
Glenn Bailey (Los Angeles Neighborhood Council Coalition (LANCC))	<p><b>Q31:</b> Are there additional safety concerns using hydrogen compared to CNG, for example? Or is that still be researched?</p> <p><b>A:</b> When you are using hydrogen, the tanks are actually very safe. Toyota and all of the hydrogen tank manufacturers conduct rigorous testing of these tanks. This testing includes fire and explosion testing and even shooting the tanks with bullets to ensure no penetration occurs.</p>
David Teichroeb (Triple E Energy Advisors)	<p><b>Q32:</b> The SCAQMD Hydrogen Blended Natural Gas in NZE Engine Emissions Study is scheduled to wrap up December 2021. Does this still include the lifecycle/maintenance study work as well, or is this a different project?</p> <p><b>A:</b> No. The maintenance study and lifecycle are part of a different project, so they're going in conjunction with each other, We're first looking at the emissions profile of hydrogen blends and natural gas, and after that we will look at the maintenance and life cycle one and durability.</p>
Claire Becker-Castle (SoCalGas)	<p><b>Q33:</b> Does SoCalGas have any collaborative projects with Southern California Edison in regard to vehicles that run on hydrogen fuel cells?</p> <p><b>A:</b> Not currently, but we're definitely open to collaborating on this topic.</p>



Name	Questions & Comments
Paul Sandsted (Natural Gas Vehicles for America)	<p><b>Q34:</b> California's transportation decarbonization goals would be best served by fueling vehicle applications with RNG as it offers the lowest lifecycle carbon intensity of any other vehicle fuel available today—including renewable electric—due to its carbon-negative potential.<sup>46</sup></p> <p><b>A:</b> The California Air Resources Board's LCFS program reports all certified fuel pathways with their respective carbon intensities. Several RNG production pathways (listed as Bio-CNG by CARB) have been certified with negative carbon intensities.<sup>47</sup></p>

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#### CLEAN GENERATION

Jamie Ormond (CPUC)	<p><b>Q35:</b> RE specific area 2, are there big fuel cell technology improvements on the horizon that we should know about?</p> <p><b>A:</b> Within the research community and the solid oxide fuel cell industry, there is work being done to incorporate hydrogen blending and carbon capture, and to improve cycling durability and fast-ramping ability.</p>
Jack Chang (CPUC)	<p><b>Q36:</b> Can you speak more to whether and how distributed generation resources will target particular communities, such as those that experience more PSPS events? Or more low-income communities?</p> <p><b>A:</b> The RD&amp;D Program team is working to help develop and demonstrate new low emissions distributed generation technologies of various sizes that specifically address the needs of those customers affected by Public Safety Power Shutoff (PSPS) events. The work being done in the Distributed Generation and Integration &amp; Controls subprograms aims to reduce upfront capital and operating costs of distributed generation and microgrid technologies so more people can afford the resilience those technologies provide.</p>
Norman Pedersen (Hanna and Morton, LLP)	<p><b>Q37:</b> Is there any connection between the DERS RD&amp;D that you presented and the DERS Tariff which was approved in D.15-10-049 and which was the subject of the 10/20/20 SoCalGas Petition for Modification of D.15-10-049?</p> <p><b>A:</b> The technology developed in the Distributed Generation subprogram has the ability to become eligible for the Distributed Energy Resources Service (DERS) Tariff when it is commercialized. The SoCalGas team that manages the DERS Tariff is one of the internal stakeholders that the RD&amp;D Program team works with to identify technology gaps and opportunities.</p>

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<sup>46</sup> Ngvamerica, *Which Road to Take?*, available at <https://ngvamerica.org/wp-content/uploads/2020/10/NGVamerica-Which-Road-TX-vs-CA-Investments.pdf>.

<sup>47</sup> California Air Resources Board, *LCFS Pathway Certified Carbon Intensities*, available at <https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>.

Name	Questions & Comments
Jamie Ormond (CPUC)	<p><b>Q38:</b> Regarding GHG emissions, are you working on doing emissions comparisons and reporting comparisons between distributed generation technologies, such as fuel cells versus engines/turbines? Where/when will these reports become available?</p> <p><b>A:</b> At this time, we do not have any projects directly comparing fuel cells and engine/turbine-based distributed generation. Assuming similar fuel sources (natural gas), GHG reductions provided by fuel cells are a result of the higher efficiency when compared with traditional generation technologies. When evaluating the system performance of new technologies, we do measure system efficiency, from which GHG emissions can be calculated. We have several projects that explore hydrogen blending in distributed generation technologies, a practice that reduces the GHG emissions of these systems.</p>
Norman Pedersen (Hanna and Morton, LLP)	<p><b>Q39:</b> Where are the 2020 SoCalGas RD&amp;D Report and today's slides posted on the SoCalGas website?</p> <p><b>A:</b> The 2020 Annual Report and a recording of the workshop can be found at the following link: <a href="https://www.socalgas.com/clean-energy/research-and-development">https://www.socalgas.com/clean-energy/research-and-development</a>.</p>
Jamie Ormond (CPUC)	<p><b>Q40:</b> Are you seeing new control technologies for fuel-cell-based microgrids that seem cool?</p> <p><b>A:</b> We recently started a project with GTI to evaluate a new technology that provides a “microgrid-in-a-box,” complete with full-time power factor correction, the ability to incorporate gas generation, and individual load circuit modeling. We are also looking into the opportunity to evaluate the ability of a commercially available microgrid control platform to work with residential fuel cells.</p>

#### CUSTOMER END-USE APPLICATIONS

Brandon Iglesias (Reactwell)	<p><b>Q41:</b> Would your team be interested in collaborating with our team at Reactwell to further mature a renewable natural gas working electrode based on carbon nanospikes? If so, what is the best way to engage? Within "Advanced Innovation," our team has an IoT product called "Equipment Energizer" that can help with equipment/appliance efficiency and energy monitoring. Would this be of interest to you?</p> <p><b>A:</b> Thank you for sharing this technology with the RD&amp;D Program team. We look forward to learning more about it. We encourage you to submit a research concept proposal for staff to consider at <a href="mailto:RDDinfo@socalgas.com">RDDinfo@socalgas.com</a>. Remember that the RD&amp;D Program team evaluates proposals based on several factors, including Lead Investigator/Team, Technical Feasibility, Strategic Fit, Co-funding Collaborators, Commercialization Potential, Customer Benefit, and Equity Considerations (Section 1.4). For more information about the Customer End-Use Application program, see also page 46 of the 2020 RD&amp;D Annual Report.</p>
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Name	Questions & Comments
Jack Chang (CPUC)	<p><b>Q42:</b> What are the advantages of using gas heat pump residential water and space heaters compared to electric heat pump heaters? Can gas heat pump heaters help create zero-emission buildings as California is encouraging?</p> <p><b>A:</b> Thank you for your question. Gas heat pumps provide a new product category that can achieve operating efficiencies of approximately 130%. Compared to conventional gas-fired storage water heaters, gas heat pumps provide a near-term solution that offers 50% GHG emissions reductions, which could enable the building sector to achieve the necessary 40% GHG reduction levels by 2030.</p> <p>With the introduction of hydrogen blends into the pipeline, we expect the GHG emissions reduction potential to be much greater for end-use appliances. Decarbonized fuels coupled with energy efficiency can drive significant GHG reductions. Therefore, the high efficiency offered by gas heat pumps coupled with the unit-tolerance for hydrogen blends up to approximately 30% would result in an approximately 80% reduction in GHG emissions. Gas heat pumps along with decarbonized fuels will help create the zero-emission buildings that we are all working towards.</p>
Deanna Haines (SoCalGas)	<p><b>Q43:</b> Aren't some of the gas heat pumps devoid of using high GWP refrigerants? This is a more important issue from a GHG perspective.</p> <p><b>A:</b> Thank you for your question. The advantage of gas heat pump is that it uses climate-friendly natural refrigerants such as ammonia which has a zero global warming potential (GWP).</p>
Payam Heydari (UC Irvine)	<p><b>Q44:</b> Could you elaborate more on 3D multi-sensor transmitters? What is the resolution you are looking for? Why only transmitters and not receivers?</p> <p><b>A:</b> Thank you for your question. 3D multi-sensor transmitters are an example of a new technology that might fall under the advanced innovation subprogram. This subprogram is a catch-all for new and interesting technologies that might not fit in with the other subprograms. We are, however, interested in stakeholder input regarding how that kind of technology could play a role in achieving energy efficiency or building decarbonization. Could virtual reality or augmented reality be used as a training tool or a building analysis technique? We are seeking guidance from experts in this area.</p>
Thomas Harris (Reactwell)	<p><b>Q45:</b> Would SoCal Gas be interested in renewable ethanol production for homes that can't install gas?</p> <p><b>A:</b> Thank you for sharing this technology with the RD&amp;D team. We look forward to learning more about it. We encourage you to submit a research concept proposal for staff to consider at <a href="mailto:RDDinfo@socalgas.com">RDDinfo@socalgas.com</a>. Remember that the RD&amp;D team evaluates proposal based on several factors including Lead Investigator/Team, Technical Feasibility, Strategic Fit, Co-funding Collaborators, Commercialization Potential, Customer Benefit, and Equity Considerations. Refer to section 1.3 of the 2022 RD&amp;D Research Plan for more detail regarding Project Selection Criteria and page 46 of the 2020 RD&amp;D Annual Report for more information on the Customer End-Use Applications program.</p>

Name	Questions & Comments
Jack Chang (CPUC)	<p><b>Q46:</b> Can you compare next-generation burners with induction cookstoves? Again, how would next generation burners impact zero-emission building pushes?</p> <p><b>A:</b> Thank you for your question. The commercial food service (CFS) sector is a highly energy-intensive segment with its own unique challenges. CFS customers are a hard-to-reach customer base and purchase decisions have traditionally been driven by upfront cost rather than total cost of ownership. However, with the disruption we've seen due to recent economic events, restaurant operators will be more conscious of the cost of ownership due to an even tighter profit margin to stay afloat. Therefore, there will be more emphasis on bottom-line thinking and weighing first cost against long-term costs, which factor operational efficiency, parts and service, ease of operation, and high versus low output. Another concern that CFS customers care a lot about is food quality. For example, a bakery might not be able to sell its baked goods as successfully if the crust on its bread or other baked goods is not perfect. Considering all these factors, development in next-generation burners provides a lot of the needs and preferences CFS customers seek and allows for significant reductions in emissions. Therefore, energy efficiency coupled with decarbonized fuels will drive the push towards zero-emission buildings.</p>

Claire Becker-Castle (SoCalGas)	<p><b>Q47:</b> What research is SoCalGas doing on impact of hydrogen gas on burner tip for residential and commercial gas appliances as more hydrogen is in the gas?</p> <p><b>A:</b> Thank you for your question. This is an active research area for us. At this time, we have completed several projects and have additional on-going projects in this space. We have completed blending work of end-use appliances at the Engineering Analysis Center, in collaboration with UC Irvine, as well as research at other institutions like Oakridge National Laboratory. Refer to page 191 of the 2020 RD&amp;D Annual Report for more information on active and completed projects for the Customer End-Use Application program for more detail.</p>
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#### GAS OPERATIONS

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Hamidreza Aghasi (UC Irvine)	<p><b>Q48:</b> Are you interested in real-time detection and composition measurement of gases inside the pipelines or indoor/outdoor environments?</p> <p><b>A:</b> Thank you for attending our workshop. We are interested in new technologies that can help us detect the chemical composition and concentration of gases within our system. If you have technology to suggest, please email us the information at <a href="mailto:RDDinfo@socalgas.com">RDDinfo@socalgas.com</a>. Please also see the RD&amp;D 2020 Annual Report for information on projects in this area. For example, On-Line Biomethane Gas Quality Monitoring-Phase 2, Trace Sensor (OTD 7.16.e.2).</p>
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Name	Questions & Comments
Daphne D'zurko (NYSEARCH/ NGA)	<p><b>Q49:</b> The subprograms and research areas mentioned are all important. I would like to comment on the key area of technology testing: avoiding the 'valley of death,' because SoCalGas tests both internal and consortia technologies. How can we collectively assess the need in an R&amp;D portfolio for operations on how testing increases the likelihood of implementation?</p> <p><b>A:</b> Thank you for your question. One of the challenges in research and development is getting the technology from the researchers into real-life operating environments. That is certainly an area where SoCalGas provides a benefit to the development path for researchers. We participate extensively within research consortiums and host many field demonstrations in order to facilitate that step in the research and development process, which facilitates commercialization and adoption of new technologies within the operating organizations.</p>
Payam Heydari (UC Irvine)	<p><b>Q50:</b> X-ray sensing is ionizing as opposed to terahertz imaging. Is there any concern?</p> <p><b>A:</b> Thank you for your question. Part of the research evaluation is to determine if there are negative effects to materials, as well as to identify other areas of concern, which include health and safety. All of these are considered part of the research when developing or evaluating non-destructive evaluation (NDE) options.</p>
Payam Heydari UC Irvine	<p><b>Q51:</b> One of your research needs is the enhancement of acoustic, electromagnetic, and ground probing radar systems to produce complete, accurate images of buried substructures. What level of accuracy you are interested in?</p> <p><b>A:</b> Thank you for your question. One of the SoCalGas key research areas for Gas Operations is improving pipeline mapping and locating technologies. The level of accuracy varies depending upon the type of infrastructure. For example, there is a damage prevention project "Above Ground Service Tee Identification and Mapping System (OTD 8.20.J)," which has an expected level of accuracy within two feet horizontally on either side of the actual location of the pipeline and does not require a level of accuracy vertically. For other projects that are not damage prevention, there may be a vertical component required. If you provide more details of the infrastructure of interest to <a href="mailto:RDDInfo@socalgas.com">RDDInfo@socalgas.com</a>, we can provide the information.</p>
David Teichroeb (Triple E Energy Advisors)	<p><b>Q52:</b> The RD&amp;D program for Emerging Fuels - Hydrogen (Gap Analysis, Future Project Roadmap) includes the development of gas composition analysis tools for accurate, live calorific value measurement. Has SoCalGas determined yet if your gap analysis includes live calorific value and gas composition at individual meter sets (e.g., large industrial/commercial meter sets) to address future gas composition variability and energy billing accuracy due to higher-hydrogen blends? Would SoCalGas be interested in a proposal to collaborate in this smart-meter space if other utilities are doing work in this area?</p> <p><b>A:</b> Thank you for this question. With respect to the Pipeline Research Council International (PRCI) state-of-the-art analysis that was just completed in this area, we are looking at doing research in the area of metering with the introduction of hydrogen. However, we have not determined what research we will be supporting. Also, we are currently planning some full-scale demonstrations and pilots to demonstrate some of the issues related to the gas composition and how it changes between the point of insertion into the system versus point of delivery. We will gladly hear your thoughts. If you have any suggestions or can provide more information, we can use them to have a discussion with our subject matter experts. Please forward any suggestions or information to <a href="mailto:RDDInfo@socalgas.com">RDDInfo@socalgas.com</a>.</p>

Name	Questions & Comments
Claire Becker-Castle (SoCalGas)	<p><b>Q53:</b> Does SoCalGas also have proposed research to study effect of Hydrogen on steel gas pipelines in addition to plastic line?</p> <p><b>A:</b> Thank you for your question. SoCalGas has research projects underway that are looking at the impact of hydrogen blend on steel pipes. SoCalGas currently has several ongoing research projects on hydrogen blend impacts: Hydrogen Embrittlement and Crack growth studies (Phase 1A, 1B, 2A), Hydrogen Impact on Metallic Materials (OTD 6.14.B.2), and In-Service Welding onto Methane/Hydrogen Mixture Pipelines (JIP). Please refer to the 2020 RD&amp;D Annual Report for more information.</p>
Daphne D'zurko (NYSEARCH/ NGA)	<p><b>Q54:</b> I think SoCalGas is a leader in the industry in testing technologies and ideation. As folks assess the RD&amp;D program, the well-done implementation work needs to be factored into the process.</p> <p><b>A:</b> Thank you for your feedback and comment. We strive to identify barriers to implementation while research is underway by working with stakeholders to facilitate implementation into work processes. It is nice for these efforts to be acknowledged.</p>

## Appendix C: Post-Workshop Stakeholder Input

Name	Questions & Comments
Deborah McGarrey (SoCalGas)	<p><b>Q1:</b> How is SoCalGas utilizing the RD&amp;D department to further advance new technologies in public transportation?</p> <p><b>A:</b> The Clean Transportation program is working with partners to advance research in fuel cells and vehicle demonstrations across medium- and heavy-duty vehicles. We have several projects in different phases looking across the entire transportation sector. These developments include hydrogen fuel cell paratransit and shuttle buses and vans for transit, as well as integrated fuel cell powertrains for trucks and buses. We are providing co-funding to Cummins as part of a DOE-awarded project. “The first award of approximately \$3.5 million will be used towards the development of an integrated fuel cell electric powertrain for heavy-duty trucks and transit buses, one that is highly manufacturable and scalable with a proven range of 300 miles or more and improved fuel economy over current heavy-duty trucks and transit buses. The project also entails achieving, meeting, or exceeding conventional diesel powertrain performance requirements and reducing the upfront capital costs by 35%.”<sup>48</sup> The Clean Transportation program is also looking into air taxis and future public transportation technologies.</p>
John King (Hyperlight Energy)	<p><b>Q2:</b> I attended the SoCalGas RD&amp;D 2022 Research Plan webinar. It was great. It showed a concrete, [a] real plan to achieve the Aspire 2045 goals SoCalGas recently announced. It connects the dots between the announced plan and the actions necessary to achieve it. To my knowledge, Aspire 2045 is the only zero net carbon commitment from any natural gas utility in the world. In this way, SoCalGas is a world leader. As I do project and other business development activities to pitch my company’s CSP technology—Hylux™ in process heat applications to both offset natural gas for process heat, and to provide process heat for renewable natural gas production—I can say with confidence that Aspire 2045 has made a big impact on market participants. It shows there is going to be significant opportunity for low-, no-, and negative-carbon technologies, because many of these technologies are early stage, the RD&amp;D plan is crucial to provide onramps for these new technologies so that they can make a meaningful contribution between now and 2045. My own company and technology aspire[sp] to scale up and contribute significantly to this goal. The RD&amp;D Research Plan webinar was very helpful in understanding the opportunities to do just that. Please keep it up.</p> <p><b>A:</b> Thank you John! We are very pleased to see your Hylux™ technology become commercial with help from the RD&amp;D program and we are glad that our bold climate commitment is being well-received and recognized by market participants as an important step in the right direction. The RD&amp;D program will continue to explore and, as you put it, provide onramps for new technology development in support of our Aspire 2045 goals and vision.</p>
Daniel Gage (Natural Gas)	<p><b>Q3:</b> NGV America offers the following comments in regard to SoCalGas’ 2021 RD&amp;D Workshop and Request for Comments. NGV America is the national trade</p>

<sup>48</sup> HDT, TruckingInfo, *Cummins Awarded Nearly \$7 Million in DOE Grants* (August 6, 2020), available at <https://www.truckinginfo.com/10123140/cummins-awarded-nearly-7-million-in-doe-grants>.

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Vehicles for America)

organization dedicated to the development of a growing, profitable, and sustainable market for vehicles and carriers powered by clean, affordable, and abundant natural gas from both geologic and renewable sources. Our roughly 200 member companies produce, distribute, and market natural gas and biomethane, domestically manufacture and service natural gas vehicles, engines, and equipment, and operate fleets powered by clean-burning gaseous fuels across North America.

SoCalGas' RD&D program provides significant benefits to California energy consumers including those affected by and those reliant upon the transportation sector, which covers just about everyone. Of particular interest to NGV America is the work that SoCalGas has done in cooperation with governmental authorities such as the U.S. Department of Energy, South Coast Air Quality Management District, the CEC, national laboratories, and the Gas Technology Institute, to advance the development of natural gas vehicle technology.

The leadership of SoCalGas and its investments along with others' have played a critical role in the development of extremely low-polluting natural gas engine technology. As a result, virtually all the medium- and heavy-duty natural gas engine technologies available today in the U.S. are able to achieve extremely low emission levels of oxides of nitrogen and particulate matter, years ahead of what is likely to be achieved by diesel and virtually on par with electric vehicle technology when upstream or power plant emissions are considered.

In addition to advancements in engine technology, the recent developments related to renewable natural gas and the near 100 percent uptake in California are providing steep reductions in greenhouse gas emissions for new and in-use natural gas vehicles. The most recent quarterly report available from CARB reveals that the average carbon intensity of bio-CNG sold in California is now -17.95 (g/mj) [gallons per megajoule]. Few other advancements deliver such steep reductions in greenhouse gas emissions or have the capability of impacting the emissions of equipment that is already in the field. SoCalGas' contributions on bringing other new low-carbon fuels—such as hydrogen and power-to-gas—to market will provide additional opportunity to lower emissions with natural gas vehicle technology.

Unfortunately, the latest guidance from the Public Utilities Commission precludes SoCal from continuing to use available RD&D funding to advance the development of near-zero natural gas engine technology and must instead use resources only for zero-emission technology. The explanation is that near-zero is no longer sufficient or in line with the state's goals and objectives for transportation. This viewpoint ignores the enormous strides made in reducing emissions from internal combustion engines and also ignores the fact that there is still opportunity to lower the emissions from near-zero engines, as evidenced by the fact that CARB recently adopted changes to its near-zero regulations to lower the requirements.

It is understandable that there is a desire to see zero-emission technology as "the" solution for transportation. However, it is not realistic to believe that zero emission technology will be the only solution—especially when net-zero NGV technology is production ready for large-scale deployment today—and we believe it is short-sighted to preclude funding for extremely low-polluting technologies that might prove to be the only viable solution to displace diesel engines in a variety of

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applications. The noted continued interest in natural gas by major national fleets gives support to the importance of supporting further improvements to natural gas technology. Fleets such as Waste Management, UPS, Anheuser-Busch, and Amazon all have made recent commitments to expand their investments in natural gas, particularly because it meets their desire to lower emissions and meets a need not met by other vehicle technologies.

The good news is that near-zero-emission engines using renewable natural gas can deliver carbon-neutral and even carbon-negative emission results and virtually eliminate criteria pollutants, providing much needed emission reductions for California. Additional improvement to near-zero-emission engines, including further lower emissions and improving efficiency by utilizing hybrid-electric systems, provide a pathway to even greater benefits. With hybridization comes the ability to operate natural gas-powered vehicles in all electric operation for certain distances, delivering zero tailpipe emissions in and around areas that require a total reduction in exposure to emissions (*e.g.*, warehouse districts, schools, hospitals, tunnels, etc.). The improvements and continued advancements are not only likely to be extremely competitive with battery electric vehicles but in some cases to demonstrate lower well-to-wheels carbon intensity and prove to be the only viable or feasible option.

Prohibiting SoCalGas from supporting RD&D associated with near-zero-emission natural gas technology is likely to forestall development and certainly will contribute to a delay in the achievement of the benefits associated with bringing these technologies to market. We therefore respectfully request that the RD&D program once again include much needed funding for natural gas vehicle programs.

**A:** Thank you for your feedback and comment. SoCalGas RD&D has had a long history developing natural gas technologies for natural gas and will continue to assess the need for funding for natural gas vehicles.

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**Q4:** Hope this email finds you well. Thank you very much for the very informative workshop! Based on the workshop information, we are proposing a number of solutions that can address some of your research needs. In particular, we propose miniaturized green technology for precise pipeline locating, monitoring, and mapping using a novel high-resolution sensing/radar technology. Specifically:

Prof. Hamidreza Aghasi  
(Nanoscale Communication IC Labs, High Speed Integrated electronics Lab, UC Irvine)

- Precise pipeline locating, monitoring, and mapping using a novel high-resolution sensing/radar technology
- Continuous detection and measurement of gas composition inside the pipeline using non-ionizing terahertz gas spectroscopy technology

Could you please help us understand how we can engage with SoCalGas to address these research needs? Per request, we are also available to meet online and present more details of our technologies. We look forward to hearing from you!

**A:** Thank you for your feedback and comment. We are interested to hear about the technology and the potential end-use for this new spectroscopy technology. Please contact the group through [RDDinfo@socalgas.com](mailto:RDDinfo@socalgas.com) with information about the technology. It will be directed to the appropriate RD&D program for evaluation. You will be contacted if more information is needed. Information on projects that have

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been completed or are currently underway in these areas can be found in the RD&D 2020 Annual Report.

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**Q5:** The following are my summary comments on the SoCalGas RD&D Program Spring Workshop that was conducted on April 14, 2021:

- The workshop was generally informative and well presented.
- The presentation noted that SoCalGas will investigate blending hydrogen into pipeline gas, with a target concentration of 20% by the year 2030. What research is planned to determine the impact of various concentrations of hydrogen on compressor performance (reciprocating and centrifugal), combustion in compressor drivers, metering system performance, combustion by end-users (e.g., stove flames), and other processes? What is the basis for this 20% target concentration?
- How do the estimated cost-effectiveness of carbon capture utilization (CCU) and sequestration (CCS) technologies compare to other GHG emission reduction technologies and practices? I believe that the Department of Energy and others have been testing CCS technologies for many years without developing a viable technology. The presentation (slide 60) includes a quote from LLNL "[To reach carbon neutrality by 2045] California will likely have to remove on the order of 125 million tons per year of CO<sub>2</sub> from the atmosphere" and a Technical Target of \$100/ton-CO<sub>2</sub> captured by 2030 for Direct Air Capture (slide 61). This equates to \$12.5 billion per year. To provide perspective, \$12.5 billion is about a factor of three greater than SoCalGas revenues in 2020. Further, this estimate is based on a Technical Target, not an established technology, and costs could be much higher in practice.

Thomas McGrath  
(Innovative  
Environmental  
Solutions)

**A:** Thank you for your feedback. SoCalGas appreciates the opportunity to clarify that the goal is 20% RNG by 2030, not 20% hydrogen by 2030. SoCalGas understands the concerns about gaps in introducing hydrogen into its infrastructure. Alongside internal efforts, SoCalGas is part of several consortia doing internal research on the impacts of blending hydrogen into the gas infrastructure, including compressor stations, metering, end-use, and other processes. Examples of these consortia include Pipeline Research Council International (PRCI), NYSEARCH, and the Low Carbon Resources Initiative (LCRI), a joint effort between Gas Technology Institute (GTI) and Electric Power Research Institute (EPRI). In November 2020, SoCalGas submitted an assessment of technical considerations for hydrogen blending in its Joint Investor-Owned Utility (IOU) Application – Preliminary Hydrogen Blending Injection Standard. Chapter 4 of the application notes that individual components of the gas system have different as-is blend percentage capabilities. Some components need more study, and some may be able to be modified to target higher blend percentages. However, SoCalGas has not set a hydrogen blend percentage target.

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**Q6:** I suggest that a large focus of future research should be on reducing methane emissions due to the high global warming potential of methane.

Thomas McGrath  
(Innovative  
Environmental  
Solutions)

**A:** Thank you for your feedback. RD&D does have several projects in reducing methane and other greenhouse gas (GHG) emissions from its compressor stations. These projects are funded through PRCI under its SRP program, as mentioned in our

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annual report. We also have an SB 1371 group that focuses on emissions from pipeline and compressor stations. This group focuses on the detection and mitigation of fugitive methane leaks.

Daphne D’Zurko  
(NYSEARCH/ NGA)

**Q7:** I think that given our role as a collaborative research entity for 20 LDCs in N. America and the active participation that we see from the SoCalGas RD&D Program, we are aware that all research areas that are in the SoCal Gas Operations program are on point. The subprograms are aligned with NYSEARCH program areas and support future industry growth and innovation.

**A:** Thank you for your feedback and comments. SoCal Gas has benefitted tremendously in collaborating with NYSEARCH and its members in research projects that are beneficial to SoCalGas and the utility industry.

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Daphne D’Zurko  
(NYSEARCH/ NGA)

**Q8:** Through collaborative research, such as with GTI/OTD, NYSEARCH and PRCI, there are economies of scale that provide leverage to SoCalGas on its RD&D investment of funds and time. Other members of these collaboratives bring diverse expertise and test variability as well as resources. In my opinion, SoCalGas is uniquely positioned at this time to facilitate the evaluation of RD&D results. They serve as a leader and their program is a benchmark to guide industry organizations and to meet the needs of ratepayers.

**A:** Thank you for your comments. SoCalGas has been working diligently with NYSEARCH to ensure that the research areas that NYSEARCH focuses on for SoCalGas remain on point for SoCalGas consumers, while participating in viable research that will benefit its ratepayers through advancement in energy technologies. Please contact the group for more details through [RDDinfo@socalgas.com](mailto:RDDinfo@socalgas.com).

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Daphne D’Zurko  
(NYSEARCH/ NGA)

**Q9:** With increased attention on decarbonization and a myriad of challenges, numerous organizations are active, but not all are as well equipped to demonstrate and validate what works in the laboratory and in controlled and live conditions. Thus, I think that the RD&D evaluation team needs to fully assess the resources that are going to be needed to validate a range of new technologies and allow reasonable timeframes to complete in-field and related validation testing.

**A:** Thank you for your comment and question. Yes, SoCalGas works in collaboration with other utility members to ensure a thorough study is complete, if necessary, through literature searches and gap analyses on the research projects before transitioning to field trials. Some projects will undergo a Go/No-Go phase to determine if they are feasible to proceed to field trials and contract vendors in order to be able to perform complete field and lab studies. Please see the SoCalGas 2020 Annual Report for more information on our various projects and our project cycle.

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Daphne D’Zurko  
(NYSEARCH/ NGA)

**Q10:** In order to sustain and strengthen the RD&D program, how can SoCalGas continue to maintain high participation in testing technologies in the field in all selected areas of work? Thanks for the opportunity to provide the additional feedback and a question.

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**A:** Thank you for your feedback and question. SoCalGas has a strong participation rate in testing technologies in the field. Please refer to the 2020 RD&D Annual Report for reference.

Brandon Iglesias  
(Reactwell)

**Q11:** My name is Brandon Iglesias. I attended your public RD&D webinar last week, and I have a Health, Safety & Environmental (HSE) suggestion for your Advanced Innovation subprogram within Customer End-Use Applications, as well as Gas Operations Program. Our company, Reactwell, has been working on the Safety Spot project since 2014. Safety Spot is an IoT software and hardware platform that provides a 3D safety training, equipment management, equipment maintenance, analytics, reports, people management, shut-off devices, energize devices, sensors, and prototyping electrochemical converters for CO<sub>2</sub> utilization in products, such as sanitizer generated on-site. Our organizational software can immediately help SoCalGas achieve its goals of greater operational efficiency and greater safety. Our hardware capability is appropriate for further RD&D [Program] project scoping. I hope that one or more of [our] applications could be useful to your utility.

**A:** Thank you for your feedback. Please see our thoughts on your product questions below.

**Q12:** Our Safety Spot 3D training software platform is commercially available. Our software is already used by many commercial customers, such as universities, to store training materials and records for up to thousands of individuals in one digital location. The software tracks training completion and can send automated alerts/reminders. The software also provides one digital location for physical assets (like equipment or fleet vehicles). Required employee training and important resources like manuals can be directly linked to an asset's "home page" for quick reference. It can also provide 3D training on equipment and environment for situational awareness. Perhaps this would be useful to better message to the public how SoCalGas' renewable energy projects work. An example would be a concerned citizen exploring a renewable natural gas site virtually, reducing risks and costs, but enabling increased public awareness of the STEM-enabled advances your firm is making, powered by Safetyspot.com.

Brandon Iglesias,  
(Reactwell)

**A:** (Gas Operations) Thank you for your feedback and comment. SoCalGas has research projects underway that are looking at virtual reality for emergency training and B31Q training documentation portal. We are interested to hear about the technology and the potential uses cases. Please contact the group through [RDDinfo@socalgas.com](mailto:RDDinfo@socalgas.com) with information about the technology.

(Customer End-Use Applications) Thank you for sharing this technology with the RD&D Program team. We look forward to learning more about it. We encourage you to submit a research concept proposal for staff to consider at [RDDinfo@socalgas.com](mailto:RDDinfo@socalgas.com). Remember that the RD&D Program team evaluates proposals based on several factors, including Lead Investigator/Team, Technical Feasibility, Strategic Fit, Co-funding Collaborators, Commercialization Potential, Customer Benefit, and Equity Considerations (Section 1.4). See page 46 of the 2020 RD&D Annual Report for more information on the Customer End-Use Application program.

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**Q13:** The IoT Equipment Energizer for Shut-off/Lock Out Tag Out or Energizing Equipment is commercially available. Our Equipment Energizer can be linked with our Safety Spot platform to control access to equipment which requires training before use. Many of our university customers are already using or planning to use this device in their student-learning machine shops. Equipment can be unlocked remotely by a supervisor, or locally by an RFID card or physical key. Restaurant fryers and natural gas cooktops (residential too) may be a good use case for this device on the natural gas line because the line is shut-off in case someone inadvertently leaves it on.

Brandon Iglesias  
(Reactwell)

**A:** (Customer End-Use Applications) Thank you for sharing this technology with the RD&D Program team. We look forward to learning more about it. We encourage you to submit a research concept proposal for staff to consider at [RDDinfo@socalgas.com](mailto:RDDinfo@socalgas.com). Remember that the RD&D Program team evaluates proposal based on several factors, including Lead Investigator/Team, Technical Feasibility, Strategic Fit, Co-funding Collaborators, Commercialization Potential, Customer Benefit, and Equity Considerations (Section 1.4). See page 46 of the 2020 RD&D Annual Report for more information on the Customer End-Use Application program.

(Gas Operations) Thank you for your feedback. SoCalGas may have an interest in this technology. Please send details of this technology to [RDDinfo@socalgas.com](mailto:RDDinfo@socalgas.com).

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**Q14:** The IoT Endless Hand Sanitizer station is under development. To help deal with the COVID-19 pandemic and sanitation in general, our parent company, Reactwell, is developing a hand sanitizer dispenser that generates its own ethanol from ambient air CO<sub>2</sub>. Using this sanitizer station instead of traditional refillable stations would reduce workload on SoCalGas's facilities staff. Use of our Endless Sanitizer would also reduce the storage space and compliance requirements for stockpiling large amounts of flammable hand sanitizer. The anode on this dispenser also can generate oxygen for medical and hospital use-cases.

Brandon Iglesias  
(Reactwell)

**A:** Thank you for sharing this technology with the RD&D Program team. SoCalGas is very interested in developing Carbon Capture and Utilization (CCU) technologies, including electrochemical conversion pathways. We would be happy to review Reactwell's technology to understand how it would fit within our portfolio of CCU projects and if it would be a complementary match with ongoing projects. Remember that the RD&D Program team evaluates proposals based on several factors, including Lead Investigator/Team, Technical Feasibility, Strategic Fit, Co-funding Collaborators, Commercialization Potential, Customer Benefit, and Equity Considerations (Section 1.4).

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Thomas Harris  
(Reactwell)

**Q15:** My name is Tom Harris, mechanical engineer at Reactwell. I attended your public RD&D webinar last week, and I have a technology development suggestion for your Low Carbon Resources Program and Clean Generation Program. Reactwell is developing a highly scalable electrochemical reactor which can produce RNG using renewable electricity. It can also produce hydrogen, ammonia (i.e., a hydrogen carrier), and ethanol in the same way. I am optimistic that our reactor will be useful for SoCalGas's goal to reduce emissions for the following reasons:

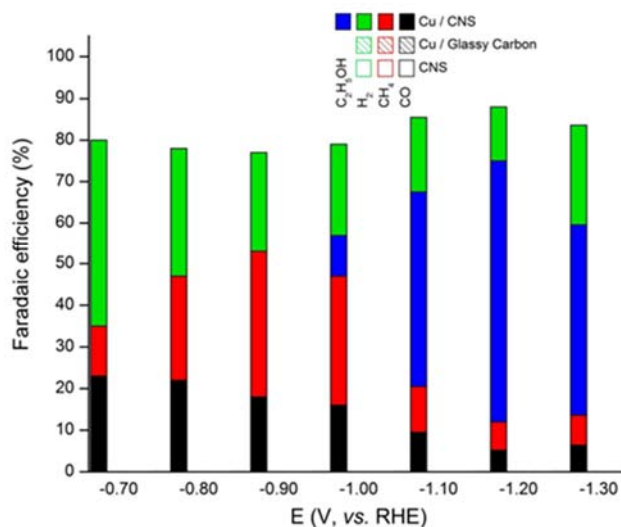
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1. The reactor can produce RNG using only electricity (i.e., solar, wind, etc.) and atmospheric water and CO<sub>2</sub>—all while operating at standard temperature and pressure. Thus, our reactor could provide SoCalGas with a truly proactive and industrial, yet scalable, method of producing RNG for its customers, enabling production in addition to and beyond rate-limited sources such as landfills—not to mention the ability to produce the RNG in any desired location.
2. Hydrogen (and ammonia as a carrier) can be produced the same way with our reactor's cathode, using only gases available in the ambient air and electricity. The anode also produces oxygen, which may be of strategic interest to hospitals and medical centers within your customer base.
3. Finally, ethanol can also be produced this way, as well on the cathode, depending upon formulation. I suggest ethanol because we have heard that some new homes in California are restricted from being connected to natural gas hookups. Thus, ethanol may be a way to fuel fireplaces and cooktops that once ran on natural gas. Our team's work to further an integrated air capture and conversion to ethanol was recently awarded a DOE:OTT:TCF-2 in the amount of \$1.5 million.

Please feel free to follow up with the Reactwell team for further information. I have also provided below links and data of our research progress with our reactor and with our partners at Oak Ridge National Laboratory:

- Ammonia from N<sub>2</sub> and H<sub>2</sub>O and electricity from renewables: <https://www.ornl.gov/news/novel-reaction-could-spark-alternate-approach-ammonia-production> [ornl.gov]
- Ethanol from CO<sub>2</sub> and H<sub>2</sub>O and electricity from renewables: <https://www.ornl.gov/news/nano-spike-catalysts-convert-carbon-dioxide-directly-ethanol> [ornl.gov]
- Faradaic Efficiency data for RNG, ethanol, and H<sub>2</sub> production:

## Result: Products from CO<sub>2</sub> Conversion



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**A:** Thank you for sharing this technology with the RD&D Program team. We look forward to learning more about it. We encourage you to submit a research concept proposal for staff to consider. Remember that the RD&D Program team evaluates proposals based on several factors, including Lead Investigator/Team, Technical Feasibility, Strategic Fit, Co-funding Collaborators, Commercialization Potential, Customer Benefit, and Equity Considerations (Section 1.4).

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**Q16:** GTI enthusiastically supports SoCalGas’ proposed 2022 research, development, and deployment (RD&D) program, as outlined in the April 14, 2021 workshop. The RD&D program is squarely focused on decarbonizing the energy sector in California while providing substantial benefits to California energy consumers to ensure a resilient, reliable, affordable, and safe transition to a cleaner energy future. The program specifically continues SoCalGas’ focus on reducing GHG emissions to address the climate goals of California through program areas including Low Carbon Resources, Clean Transportation, Gas Operations, Clean Generation, and Customer End-Use Applications. These programs continue to lead utilities throughout the country showing commitment and creativity in developing and testing new technologies and guiding the way to a lower carbon energy future.

In California and throughout the United States, as lower carbon and even negative-carbon gases continue to be added to the gas system, energy efficiency continues to play a critical role in reducing GHG emissions. Developing affordable state of the art, thermal heat pumps will provide a means to continue the resiliency the gas system offers to consumers while dramatically increasing performance efficiencies to near 150% to help achieve the net zero goals of the state. Energy efficiency improvements across all end-use applications continue to be an important and large contributor to the reduction of GHG emissions in California.

Dan LeFevers (State and Consumer Programs, GTI)

Additionally, gas infrastructure will play an important role as the future largest storage mechanism for renewable energy from electrolysis (power-to-gas) and gas created from the capture and conversion of biogenic feedstocks. The existing gaseous storage, delivery, and distribution infrastructure can play a critical long-term role as a cost-effective means for utilization of excess renewable energy represented in the “duck curve.” The SoCalGas RD&D program will help catalyze this opportunity and develop the technologies, guidance, and mechanisms to create cost-effective approaches to long-term renewable energy storage, without which the state cannot meet its GHG emission reduction goals.

One critical component of transforming the gas infrastructure to safely and reliably deliver and store zero carbon gases including hydrogen and RNG will be the continuation and enhancement of R&D in the area of Gas Operations and Utilization. This R&D ensures that the transition of the gas infrastructure to deliver and store these types of gases will continue in a safe and reliable manner as has been the case with natural gas over these past many decades, and that end-users will safely use these types of gases in their appliances, equipment, and processes.

Another important aspect of the SoCalGas RD&D program is the ongoing coordination with the RD&D programs of the California Energy Commission (CEC), California air agencies and universities, GTI, the U.S. Department of Energy, and

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many other research organizations in and outside of California. This coordination leads to leveraged funding and knowledge, as well as assists in finding demonstration sites and project participants to validate advanced technologies. SoCalGas' engagement significantly influences the actions of other energy delivery operators throughout the world and works to ensure that new technologies are quickly accepted in the marketplace to benefit energy consumers. As summarized in the Appendix of SoCalGas' RD&D Program 2020 Annual Report, California natural gas ratepayers' dollars are highly leveraged to support these critical RD&D initiatives that result in technologies and approaches that increase efficiency and safety while improving the environment.

New technologies, ones that reduce carbon emissions and even capture carbon, will continue to be developed over the next couple decades. These technologies will need to be refined, improved, tested, and changed. The SoCalGas R&D program provides a platform and funding mechanism to engage manufacturers, R&D institutions including universities and national laboratories and the energy industry at large to ensure that the technologies needed to reach net zero will be commercialized and deployed in a thoughtful and dependable manner.

The SoCalGas RD&D program is designed to deliver reliability and safety coupled with lower-carbon energy molecules and advanced technologies to ensure energy consumers will play an integral part in helping the state meet its climate goals. Additionally, these programs can help ensure that ESJ communities can benefit from cleaner and affordable energy.

Additionally, during this time of transition to new and lower-carbon energy, RD&D regarding issues of pipeline safety, natural gas system reliability, and advanced technologies to reduce GHG emissions are important to ensure California's gas infrastructure will deliver lower carbon results for energy consumers. A robust SoCalGas-managed RD&D program focused on these issues benefits from the vast experience of the company's employees and from a network of other RD&D programs, commercial companies, and California universities that bring needed expertise into the program for the benefit of California energy consumers. The SoCalGas RD&D program also funds projects at every stage of technology development where gaps may exist in other RD&D programs. These efforts ensure that important technologies that address the RD&D needs of the program can reach commercialization.

SoCalGas RD&D has also been critical to the development of many of the Near Zero Emission (NZE) engines brought to market over the last few years, through the Clean Transportation RD&D program. These past successes have significantly reduced NOx emissions and improved air quality across the state, including for many people who live and work in ESJ communities. Now with a focus on hydrogen transportation, the program can once again lead the development of advanced transportation engines paving the way for fuel cell testing and deployment in heavy- and light-duty vehicles to produce future fleets of zero-emission cars and trucks. These new hydrogen-powered vehicles will also benefit from the improvements in hydrogen fueling infrastructure that will be developed through SoCalGas' Clean Transportation RD&D program. SoCalGas-sponsored RD&D led the way in CNG infrastructure development and improvement and can do so for hydrogen.

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The energy transition, in which the utility sector is participating, will take commitment, creativity, and leadership. Getting to net zero will require the collective collaboration of many companies and organizations. To meet this goal, RD&D programs, like the one proposed and led by SoCalGas, are critical to success. The breadth of the program and its focus on decarbonization coupled with an understanding and knowledge of the value of gas infrastructure and delivery provides a unique opportunity to accelerate the decarbonization of California's energy sector. GTI supports this proposed RD&D, and we look forward to participating as a performer, co-funder, and multiplier of the SoCalGas RD&D program.

**A:** Thank you for your comments addressing several key areas of focus for the RD&D program, including decarbonizing the gas system, improving energy efficiency, safety & reliability, coordinating with the broader research community, and ensuring clean energy benefits reach ESJ communities.

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**Q17:** I would like to share my feedback about what I have seen so far of the SoCalGas RD&D program. I am not sure about the expected format of my feedback so please feel free to get back to me if you need further comments or even organize a quick call to discuss.

**Cooperation:** The cooperation with SoCalGas is smooth and fairly simple. We agreed on the scope of the project fairly rapidly (May 2020). However, SoCalGas asked for a third-party M&V [(measurement & verification) contractor] to participate in the project (which of course makes sense), which delayed [the contracting process] quite a bit. So, we were only able to get the first version of the contract by early November and, after small modification, executed the contract in the first days of 2021. At the beginning of the year, Jeff handed over the project to Alan, the Customer End-Use Applications program manager. After presenting our solution to three of SoCalGas's customers, we are now in the quick off phase of the project with The Gill Group. This is a 12-month project from here.

Pierre Groleau  
Metron

**Conclusion:** So far so good. We are now entering the operational phase. My only suggestion at this point would be to reduce the contractual phase if possible. The contracts are quite simple (which is appreciated) but took a long time to put together. Metron is also looking forward to the next possible steps of a partnership once the first project is completed. We strongly believe a cooperation between SoCalGas and Metron can help reduce CO<sub>2</sub> emissions and optimize the energy usage of SoCalGas customers.

**A:** Thank you for the feedback and support for our RD&D program. We are glad to hear that you had a positive experience with our research program and will consider the feedback you provided to improve RD&D program and procedures. We look forward to our continued collaboration with Metron in developing innovative solutions that reduce CO<sub>2</sub> emissions and improve energy optimization for SoCalGas customers.

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Ted Barnes  
(R&D Director, GTI)

**Q18:** GTI offers the following comments in regard to SoCal Gas' 2022 RD&D Workshop and Request for Comments. GTI is a leading not-for-profit research,

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development, and training organization addressing global energy and environmental challenges for over 80 years. We have spent the last eight decades developing high-impact technologies and providing technical insight to unlock the potential of energy resources—making them economically and environmentally sustainable while reducing costs for consumers. GTI has provided innovative solutions to critical challenges along the entire energy value chain and improved ways of producing, transporting, and using energy to benefit the public. We are playing a major role in advancing the use of alternative transportation fuels, with activities encompassing a broad range of fuels, including biofuels, renewable natural gas, electric vehicles, liquid propane gas, and hydrogen.

GTI would like to thank the Public Utility Commission and SoCalGas for the remarkable benefits that the SoCalGas RD&D program provides to the ratepayers of California. This letter is to specifically comment on the latest guidance from the Public Utility Commission that precludes SoCalGas from continuing to use available RD&D funding to advance the development of near-zero natural gas engine technologies and must instead use resources only for zero tailpipe emission technologies. GTI would strongly suggest that the Public Utility Commission reconsider that position. The benefits of near-zero engines and renewable natural gas are too great to ignore as they can provide near-term solutions, at the necessary scale, to help solve the enormous environmental concerns seen throughout California today.

The leadership of SoCalGas and its investments along with others' have played a critical role in the development of extremely low-polluting natural gas engine technologies. As a result, virtually all the medium- and heavy-duty natural gas engine technologies available today in the U.S. are able to achieve extremely low emission levels of oxides of nitrogen and particulate matter, years ahead of what is likely to be achieved by diesel and virtually on par with electric vehicle technology when upstream or power plant emissions are considered. Additionally, renewable natural gas and near-zero engines are being applied in non-road applications, such as rail and marine, displacing extremely high emitting sources in environmentally sensitive areas. Please allow SoCalGas RD&D funds to continue to be used for important research on renewable natural gas and near-zero emission technologies.

**A:** Thank you for your feedback and comment. SoCalGas RD&D has a long history developing new clean transportation technologies and will continue to assess the need for funding for natural gas vehicles.

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