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

Southern California Gas Company
GAS (Corp ID 904)
Status of Advice Letter 5652G
As of March 22, 2021

Subject: SoCalGas 2021 Research Development and Demonstration (RD&D) Program Research Plan in Compliance with Ordering Paragraph (OP) 30 of Decision (D.) 19-09-051

Division Assigned: Energy

Date Filed: 06-25-2020

Date to Calendar: 06-29-2020

Authorizing Documents: D1909051

Disposition:	**Signed**
Effective Date:	**03-18-2021**

Resolution Required: Yes

Resolution Number: G-3573

Commission Meeting Date: None

CPUC Contact Information:

edtariffunit@cpuc.ca.gov

AL Certificate Contact Information:

Ray Ortiz
213-244-3837
ROrtiz@socalgas.com

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

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Disposition of Filing (Accepted, Rejected, Withdrawn, etc.)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

Ronald van der Leeden
Director
Regulatory Affairs

555 W. Fifth Street, GT14D6
Los Angeles, CA 90013-1011
Tel: 213.244.2009
Fax: 213.244.4957
RvanderLeeden@socalgas.com

June 25, 2020

Advice No. 5652
(U 904 G)

Public Utilities Commission of the State of California

Subject: SoCalGas 2021 Research Development and Demonstration (RD&D) Program Research Plan in Compliance with Ordering Paragraph (OP) 30 of Decision (D.) 19-09-051

Purpose

Southern California Gas Company (SoCalGas) hereby submits this Tier 3 Advice Letter pursuant to OP 30 of D.19-09-051 requesting approval from the California Public Utilities Commission (Commission or CPUC) to record 2021 RD&D expenses to the Research, Development, and Demonstration Expense Account (RDDEA).[1]

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 General Rate Case (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.[2]

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[1] Decision Addressing the Test Year 2019 (TY 2019) General Rate Cases of San Diego Gas & Electric Company and SoCalGas, D.19-09-051 dated September 26, 2019 (the 2019 GRC Decision).
[2] Test Year General Rate Case Application of SoCalGas, A.17-10-008, 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[3] and authorized continuing the program through the TY 2019 GRC cycle at the average annual funding level requested by SoCalGas.[4] In addition, D.19-09-051 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.*[5]

The Commission also required that prior to SoCalGas recording 2021 RD&D expenses to the RDDEA balancing 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*
> *(3) discuss how SoCalGas incorporated feedback from workshop stakeholders and Commission staff.*[6]

[3] D.19-09-051 at Findings of Fact (FOF) 169, 170, and 171.
[4] *Id.* at 381.
[5] *Id.* at OP 30.
[6] *Id.* at 379.

Discussion

In accordance with the 2019 GRC Decision, SoCalGas RD&D staff completed the following activities to develop the 2019 Annual Report and 2021 Research Plan:

2019 Annual Report: On April 17th, 2020, SoCalGas published and submitted to CPUC Energy Division staff for review its 2019 RD&D Annual Report.[7] The report includes a summary of ongoing and completed projects, funds expended, funding recipients, 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.

2021 Research Plan Outreach: To engage relevant stakeholders and solicit input, RD&D staff interviewed 25 representatives from a variety of research organizations including the California Energy Commission (CEC), Gas Technology Institute, and U.S. Department of Energy. On April 24, 2020, RD&D staff hosted a public workshop via an online platform.[8] In consultation with Energy Division staff, SoCalGas also extended invitations to and encouraged participation from 160 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 180 individuals from over 70 organizations, including the CPUC, CEC, Gas Technology Institute, Department of Energy, South Coast Air Quality Management District, Council of Mexican Federations in North America, Habitat for Humanity Greater Los Angeles, Proteus Inc., Mexican American Opportunity Foundation, Los Angeles Conservation Corps, Union of Concerned Scientists, University of California, Irvine, 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. Input from stakeholders[9] led to the inclusion of additional detail in the proposed budget allocation, a more comprehensive description of the Project Selection Process, the addition of Equity Engagement to the plan, and the acceptance of modified sub-program names. Post-workshop comments from a community member and post-workshop interviews with a CPUC Senior Equity Analyst and stakeholders, including Hispañas Organized for Political Equality, California State University, Los Angeles, University of California, Los Angeles Luskin Center for Innovation, greatly informed the design of Equity Engagement Activities for 2020-2021.[10]

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[7] The report is available for download at https://www.socalgas.com/smart-energy/research-and-development.

[8] A recording of the workshop is available to view online at https://www.socalgas.com/smart-energy/research-and-development.

[9] Detailed input from stakeholders can be found in Appendices A – C of the 2021 Research Plan, which is attached to this Advice Letter as Attachment A.

[10] For more detail of how stakeholder input was incorporated into the Research Plan, refer to section 1.3.5 of Attachment A – "Incorporating Stakeholder Feedback."

In addition, RD&D staff engaged CPUC Energy Division staff early on in the development process and held in-person and virtual meetings through the first and second quarters of 2020 to review the 2019 Annual Report and 2021 Research Plan as the team progressed toward the final documents.

Summary of 2021 Research Plan

The RD&D program is divided into five program areas: Low Carbon Resources, Gas Operations, Clean Transportation, Clean Generation, and Customer End-Use Applications. Each program area is further divided into multiple sub-program areas. The Research Plan, which is provided as Attachment A, describes how projects in each sub-program area help improve reliability, safety, environmental benefits, or operational efficiencies.[11]

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 TY 2019 GRC decision to 2021 dollars. For 2021 the escalated, authorized funding amount is $16.18 million.

To allocate the 2021 budget, first, the Program Administration costs were forecast. Next, each sub-program identified the level of funding that will be spent in 2021 with a high degree of certainty. This funding includes projects that are currently under contract, projects that are in the contracting process, and projects submitted to external funding opportunities. Finally, each sub-program identified funds for projects that are under development for 2021. This funding is allocated to support projects in these key research areas for which some uncertainty in timing or budget remains. The key research areas are examples of potential interest that could be funded if the appropriate projects are developed. Funds may also be redirected to new research areas that arise during the plan year. Table A below provides a summary of the 2021 RD&D budget by research sub-program area.

[11] 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 Attachment A (*e.g.*, 2.2.2 for Renewable Gas Production, 2.3.2 for Low Carbon Hydrogen Production, etc.).

Table A: 2021 RD&D Program Budget

Programs	2021 Forecast Program Level Funding	Sub-Programs	2021 Sub-Program Level Forecast Funding
Low Carbon Resources	$ 5,424,200	Renewable Gas Production	$ 1,500,000
		Low Carbon Hydrogen Production	$ 2,924,200
		Low GHG Chemical Processes	$ 1,000,000
Gas Operations	$ 3,518,400	Environmental & Safety	$ 652,311
		Operations Technology	$ 285,553
		System Design and Materials	$ 1,743,227
		System Inspection & Monitoring	$ 837,309
Clean Transportation	$ 2,052,400	On-Road	$ 935,424
		Off-Road	$ 809,600
		Refueling Stations	$ 134,582
		Onboard Storage	$ 172,794
Clean Generation	$ 1,612,600	Integration & Controls	$ 806,300
		Distributed Generation	$ 806,300
Customer End-Use Applications	$ 2,052,400	Commercial Food Service	$ 157,600
		Residential Appliances	$ 900,600
		Commercial Applications	$ 235,715
		Industrial Process Heat	$ 620,570
		Advanced Innovation	$ 137,915
Program Administration	$ 1,520,000	Program Administration	$ 1,520,000
Total:	$ 16,180,000		

Protests

Anyone may protest this Advice Letter to the Commission. The protest must state the grounds upon which it is based, including such items as financial and service impact, and should be submitted expeditiously. The protest must be made in writing and received within 20 days of the date of this Advice Letter, which is July 15, 2020. The address for mailing or delivering a protest to the Commission is:

CPUC Energy Division
Attn: 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 Energy Division Tariff Unit (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 address 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

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. SoCalGas respectfully requests that it be approved by the Commission by December 1, 2020 to support planning and initiation of 2021 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 by e-mail to Tariffs@socalgas.com or call 213-244-2837. For changes to all other service lists, please contact the Commission's Process Office at 415-703-2021 or by e-mail at Process_Office@cpuc.ca.gov.

/s/ Ronald van der Leeden
Ronald van der Leeden
Director - Regulatory Affairs

Attachments

California Public Utilities Commission

ADVICE LETTER SUMMARY

ENERGY UTILITY

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

Company name/CPUC Utility No.:

Utility type:

☐ ELC ☐ GAS ☐ WATER

☐ PLC ☐ HEAT

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

EXPLANATION OF UTILITY TYPE

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

(Date Submitted / Received Stamp by CPUC)

Advice Letter (AL) #:

Tier Designation:

Subject of AL:

Keywords (choose from CPUC listing):

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

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

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

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

Confidential treatment requested? ☐ Yes ☐ No

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

Resolution required? ☐ Yes ☐ No

Requested effective date:

No. of tariff sheets:

Estimated system annual revenue effect (%):

Estimated system average rate effect (%):

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

Tariff schedules affected:

Service affected and changes proposed[1]:

Pending advice letters that revise the same tariff sheets:

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

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

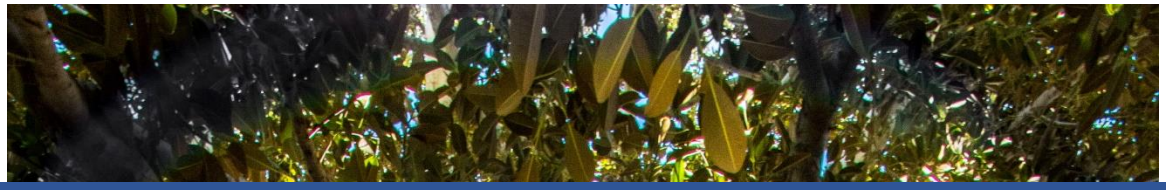
CPUC, Energy Division Attention: Tariff Unit 505 Van Ness Avenue San Francisco, CA 94102 Email: EDTariffUnit@cpuc.ca.gov	Name: Title: Utility Name: Address: City: State: Zip: Telephone (xxx) xxx-xxxx: Facsimile (xxx) xxx-xxxx: Email:
	Name: Title: Utility Name: Address: City: State: Zip: Telephone (xxx)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

ATTACHMENT A

Advice No. 5652

2021 SoCalGas Research Development and Demonstration Program Research Plan

SoCalGas A Sempra Energy utility®



2021
Research, Development, and Demonstration Program
Research Plan

2021 SoCalGas RD&D Research Plan

Table of Contents

List of Abbreviations

AB	Assembly Bill
AE	Account Executives
AQMP	Air Quality Management Plan
ARPA-E	Advanced Research Projects Agency-Energy
BETO	Bioenergy Technology Office
BTO	Building Technology Office
CARB	California Air Resources Board
CBO	Community-Based Organization
CCS	Carbon Capture and Sequestration
CCST	California Council on Science and Technology
CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Utilization, and Storage
CEC	California Energy Commission
CFR	Code of Federal Regulation
CFS	Commercial Food Service
CH4	Methane
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CNTP	Catalytic Non-Thermal Plasma
CO2	Carbon Dioxide
CPUC	California Public Utilities Commission
CSP	Concentrated Solar Power
CSULA	California State University, Los Angeles
CTP	Clean Transportation Program
DAC	Disadvantaged Community
DEF	Diesel Exhaust Fluid
DG	Distributed Generation
DME	Dimethyl Ether
DOE	U.S. Department of Energy
DOT	Department of Transportation
EAC	Environment-Assisted Cracking
EERE	Energy Efficiency and Renewable Energy
EGR	Exhaust Gas Recirculation
EMAT	Electromagnetic Acoustic Transducer
EPA	Environmental Protection Agency
EPIC	Electric Program Investment Charge
EO	Executive Order
ERDD	Energy Research and Development Division
ESJ	Environmental and Social Justice
FPIP	Food Production Incentive Program
FCTO	Fuel Cell Technology Office
g/bhp-hr	Gram per Brake Horsepower-Hour
GHG	Greenhouse Gas
GRC	General Rate Case
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation
H2	Hydrogen
HDV	Heavy-Duty Vehicles
HFCV	Hydrogen Fuel Cell Vehicle
HOPE	Hispañas Organized for Political Equity

hr	Hour
Hwy	Highway
IAQ	Indoor Air Quality
IMO	International Maritime Organization
IOT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
JCAP	Joint Center for Artificial Photosynthesis
LCFS	Low Carbon Fuel Standard
LEED	Leadership for Energy and Environmental Design
LIC	Low Income Community
LDV	Light-Duty Vehicles
LLNL	Lawrence Livermore National Laboratory
NETL	New Energy Technology Laboratory
NG	Natural Gas
NGRP	Natural Gas Research Program
NGV	Natural Gas Vehicles
NOx	Nitrogen Oxides
OIR	Order Instituting Rulemaking
OSHA	Occupational Safety and Health Administration
OTD	Operations Technology Development
PE	Polyethylene
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PM	Particulate Matter
$PM_{2.5}$	Fine Particulate Matter
PRCI	Pipeline Research Council International
Psi	Pounds per Square Inch
PSPS	Public Safety Power Shutoffs
R&D	Research and Development
RD&D	Research, Development, and Deployment
RNG	Renewable Natural Gas
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
SCR	Selective Catalytic Reduction
SJVAPCD	San Joaquin Valley Air Pollution Control District
SME	Subject Matter Experts
SMP	Sustaining Membership Program
SMR	Steam Methane Reforming
SoCalGas	The Southern California Gas Company
SOFC	Solid Oxide Fuel Cells
STARS	Meso- and Micro-Channel SMR Reactors
STEM	Science, Technology, Engineering, and Math
TAP	Technology Advancement Program
TRL	Technology Readiness Level
TWh	Terawatt-hour
UCLA	University of California, Los Angeles
U.S.	United States
USGBC	United States Green Building Council
UTD	Utilization Technology Development
VOC	Volatile Organic Compounds
ZNE	Zero Net Energy

1.0 RD&D Research Plan Overview

1.1 RD&D Program Vision, Mission, and Goals

SoCalGas is taking proactive steps to become one of the cleanest gas utilities in North America, delivering affordable, reliable, and increasingly renewable energy to its customers.

With approximately 22 million consumers and one of the nation's largest network of gas transmission, distribution, and storage infrastructure—as well as a deep network of relevant strategic relationships—SoCalGas is well positioned to play a central role in the ongoing decarbonization of California and to provide national leadership for the energy industry.

Many of the same resources that have enabled SoCalGas to become the nation's foremost gas utility have direct relevance to the company's plan to deliver cleaner energy over time, while maintaining the integrity and reliability of the pipeline system.

The SoCalGas Research, Development, and Demonstration (RD&D) Program taps into company-wide experience and expertise, shares it with knowledgeable industry stakeholders, and collaborates in the development, demonstration, and deployment of new products and technologies. The RD&D Program benefits ratepayers by helping to reduce costs, save energy, increase safety and reliability, improve air quality, and reduce greenhouse gas (GHG) emissions. Importantly, RD&D efforts are increasingly focused on ensuring that these benefits are experienced by all Californians, including those living and working in disadvantaged and low-income communities.

OUR VISION

Fostering breakthrough Innovation

OUR MISSION

To develop energy solutions that are affordable, reliable, and increasingly renewable

OUR VALUES

CULTIVATE innovation and collaboration

We work closely with universities, national labs, research consortia, businesses, public agencies, and other key stakeholders to maximize the impact of our investment.

DIVERSIFY our energy portfolio

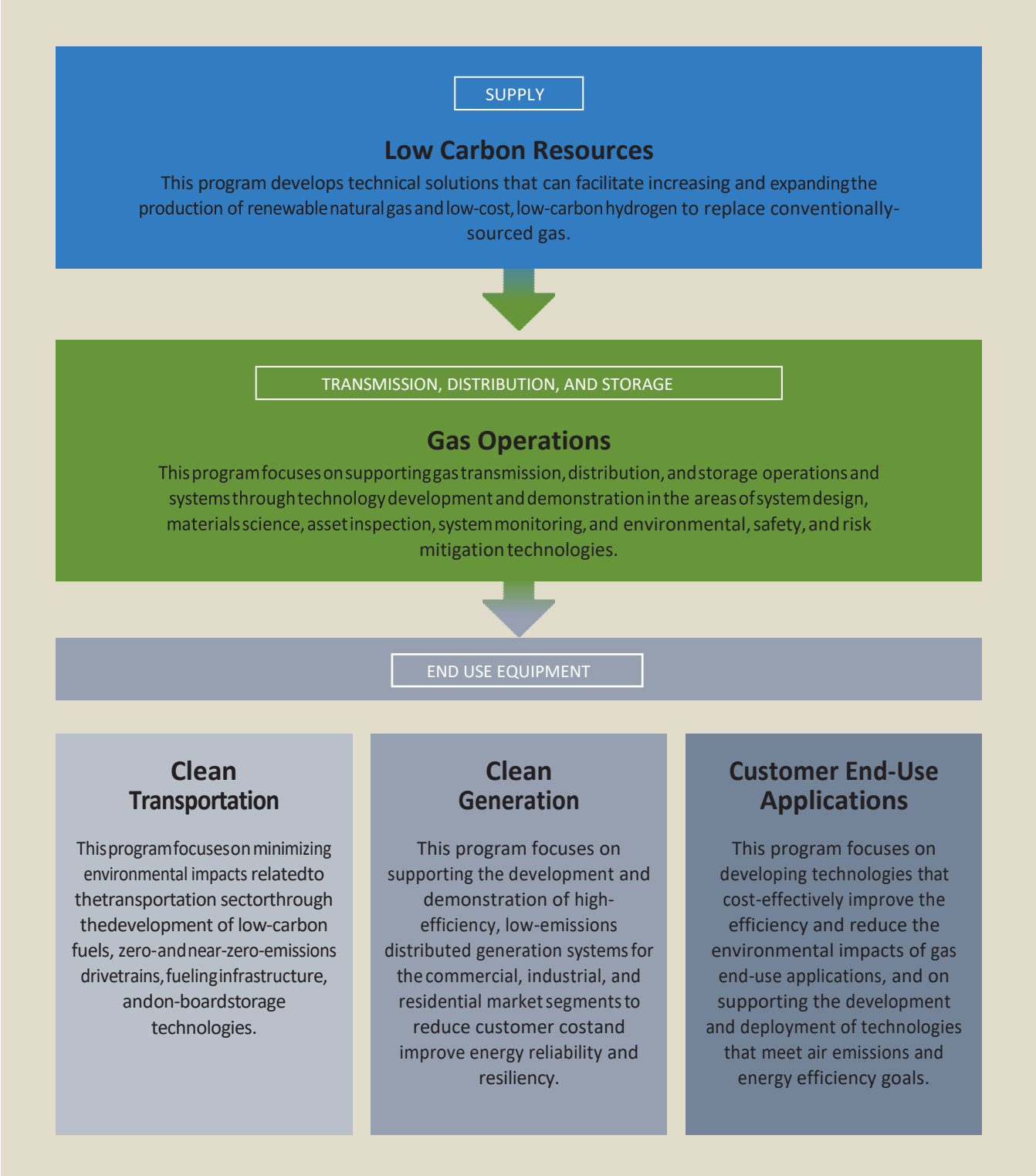
We fund promising, innovative technologies, from bench-scale to demonstration, across the entire energy supply chain.

SHAPE the future

We supplement and complement the research efforts of other R&D organizations by responding nimbly to the latest advancements in science and technology.

1.2 RD&D Program Structure and Project Selection

1.2.1 Program Structure



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

- Low Carbon Resources
- Gas Operations
- Clean Transportation
- Clean Generation
- Customer End-Use Applications

Each program area is further divided into multiple sub-program areas:[1]

Program Area	Sub-Program Area
Low Carbon Resources	Renewable Gas Production Low Carbon Hydrogen Production Low GHG Chemical Processes
Gas Operations	Environmental & Safety Operations Technology System Design & Materials System Inspection & Monitoring
Clean Transportation	On-Road Off-Road Refueling Stations Onboard Storage
Clean Generation[2]	Integration & Controls Distributed Generation
Customer End-Use Applications	Commercial Food Service Residential Applications Commercial Applications Industrial Process Heat Advanced Innovation

RD&D Program staff defined the program areas and sub-programs, as well as plans for each of those programs, after close consideration of a variety of factors, including local, state, and federal policies and regulations (Section 1.3.1); the broader energy research landscape (Section 1.3.2); input from knowledgeable industry stakeholders at the nation's universities, national labs, industry research consortia, and public agencies, including the California Energy Commission (CEC) (Section 1.3.3); input received from the California Public Utilities Commission's (CPUC) Energy Division and other interested parties in attendance at an annual workshop (Section 1.3.4); and equity (Section 1.3.5).

[1] *See* Section 1.5.1 for a detailed discussion of changes to sub-program areas in 2021.
[2] Historically, Clean Generation focused on power generating technologies and CHP applications. Given the rise of wildfire risk in California and the increase in frequency of public safety power shutoffs (PSPS), this program is expanding to allow research into microgrids to improve customer energy resiliency. Two new sub-programs are proposed.

1.2.2 Project Selection Pathways and Evaluation Criteria

When identifying promising projects and evaluating them for potential funding, RD&D Program staff follow a comprehensive yet flexible approach. One of the strengths of the program is its ability to leverage multiple, diverse pathways when identifying potential projects to fund. Because staff in each of the five programs has distinct research interests, goals, and industry relationships, each program may rely more or less heavily on the following pathways, as well as on other approaches not listed below:

1. **Addressing Internal Operation Needs**
   RD&D Program staff address the needs of SoCalGas operations through regular engagement with a large number of subject matter experts (SMEs) within the organization. These SMEs provide input into technology development strategies, review research proposals, and participate in RD&D 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.
2. **Addressing Customer Needs**
   SoCalGas Account Executives (AEs) work closely with commercial and industrial customers to identify their needs and provide timely solutions. The AEs often bring these challenges to the RD&D Program staff, seeking to identify available products or technologies to address the need, or, if none exists, to spur research aimed at advancing or developing appropriate new technologies or products.
3. **Literature Surveys, Conferences, and Workshops**
   RD&D Program staff engage in ongoing education in their areas of expertise. They regularly read technical journals, attend clean technology forums, visit national laboratories, and participate in forums held by various U.S. Department of Energy (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 New Energy Technology Laboratory (NETL). These activities enable them to stay abreast of the latest technology developments in their respective fields and better understand critical gaps in knowledge that merit further study.
4. **Research Consortia**
   RD&D Program staff leverage the national and international experience of other utilities through participation in industry research consortia, such as Utilization Technology Development (UTD) 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.
5. **External Funding Opportunities**
   When public agencies—such as the CEC or the DOE—release a funding opportunity, the RD&D Program staff often receives proposals from third-party researchers or entrepreneurs applying to the opportunity with a request for a letter of support and/or cost share from SoCalGas. Additionally, RD&D Program staff continually track various governmental funding opportunities and leverage their existing relationships with researchers and entrepreneurs to assemble a team, develop a proposal, and submit an application when a funding opportunity is identified.
6. **Proposals from Researchers**
   The RD&D Program staff has also 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 the concepts and identify relevant co-funding opportunities, demonstration project sites, or strategic partners that can enhance the quality of the project and maximize potential customer benefit.

7. **Technology Roadmap Development**
   RD&D Program staff often engage groups of SMEs to identify scientific and technological gaps as well as promising technology pathways in each program area. After identifying the gaps and pathways, the team recommends short-term pathway winners that are close to demonstration or commercialization and long-term pathway winners earlier in the development cycle. Staff then develop a detailed long-term plan to address the gaps and demonstrate the feasibility of a selected technological pathway.
8. **Public Workshops and Outreach**
   The annual RD&D Research Plan Public 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 (CBO), and the general public—to offer guidance, discuss research needs, and describe project ideas to RD&D Program staff. SoCalGas also conducts pre- and post-workshop outreach to interested stakeholders to enable longer, more thoughtful discussion about these topics. RD&D Program staff also participate in panel discussions and conferences where stakeholders present project proposals.

Once RD&D Program staff have received a project proposal, they evaluate it using, the success criteria and associated questions below:

1. **Lead Investigator/Team**
   Are the researchers, labs, or technology developers skilled and experienced in the space? Do they have a track record of success in executing research projects of a similar scope? 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?
2. **Technical Feasibility**
   Has the technology been vetted internally or externally for feasibility? Is the basic science sound? Does the technology display favorable thermodynamic modeling or technoeconomic fundamentals?
3. **Strategic Fit**
   Does the project address a key policy driver or corporate initiative? Does the project advance the state of the technology along a development roadmap? Does the research address an internal operational need?
4. **Co-funding Collaborators**
   Are other research and development (R&D) programs, government agencies, or industrial entities collaborating on the project, either via co-funding or time and expertise? Can co-funding collaborators help validate and substantiate the feasibility of the technical claims? Is co-funding available to leverage SoCalGas RD&D Program funding? Are other stakeholders supportive of the research? Is there consortium involvement to minimize the risk of duplicating work?

5. **Commercialization Potential**
   Does the proposed level of funding match the technology readiness level (TRL)? Does a clear path to commercialization exist for the technology that this research advances? Is there immediate and anticipated future demand for the proposed technology based on defined market trends and competitive advantages in comparison to the status quo or alternative technologies? Does the project team bring sufficient financial support to the project to fund multiple years of development runway? Is the project team working with established commercialization experts who have proven track records with similar products or technologies?
6. **Customer Benefit**
   Will advancing the proposed technology benefit gas utility ratepayers? If the technology becomes commercially available, how will it help SoCalGas customers, internal (i.e., SoCalGas RD&D operations teams) and external, 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 R&D organizations?
7. **Equity Considerations**
   Does the proposed technology directly address the specific needs of a disadvantaged community (DAC) or low-income community (LIC)? Is the project sited within or near a DAC or LIC? Does the project include engagement by a CBO?

1.3 RD&D Research Plan Development

RD&D Program staff consider a variety of factors in determining how to allocate funding. These factors include regulatory and policy drivers, input from knowledgeable stakeholders, input from CPUC Energy Division staff and other interested parties at an annual workshop, and equity. The process is designed to optimize sub-program level funding allocations, to provide an opportunity for stakeholder input, and to maximize progress toward overarching program goals and objectives.

1.3.1 Regulatory and Policy Drivers

Key state and federal policies and regulations impacting the RD&D Program include:

Category	Regulations & Policy Drivers
GHG Emissions	**Assembly Bill (AB) 32:** Reduce CO2 emissions 40% below 1990 levels by 2030 **Senate Bill (SB) 100:** Zero-carbon electricity by 2045 **Executive Order (EO) B-55-18:** Carbon-neutral California economy by 2045 **AB 3232:** Building decarbonization
Pipeline Safety	**CPUC General Order 112F:** Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems **DOT 49 CFR Part 192:** Federal pipeline safety regulations **AB 1900:** Biomethane quality standards
Local Air Quality	**Clean Air Act:** Air quality standards for NOx and PM **AB 617:** Pilot communities for air quality improvements

Category	Regulations & Policy Drivers
Methane Emissions	**SB 1383:** Reduce methane emissions from decomposition of organic wastes **CARB Oil and Gas Rules:** Requires new monitoring and repairs to reduce methane emissions **Natural Gas STAR Program:** Encourages adoption of methane-reducing technologies and practices **EPA Methane Challenge Program:** Recognizes oil and gas companies that take comprehensive action to reduce methane emissions
Clean Transportation	**CARB Implementation Plan:** Low-NOx standard for trucks **AB 8:** Development of 100 hydrogen fueling stations in California **EO B32-15:** Sustainable freight action plan **EO B48-18:** 200 hydrogen refueling stations by 2025 **LCFS:** Reduce carbon intensity of fuels by 10% by 2020 **SB 1275:** One million zero-emission and near-zero-emission vehicles by 2023
Microgrids	**SB 1339:** Microgrids for increased electricity reliability **CPUC R.19-09-009:** Microgrids and Resiliency proceeding
Equity	**CPUC Environmental and Social Justice (ESJ) Action Plan:** Increases investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health

Of particular note is California's Executive Order (EO) B-55-18, which calls for a carbon-neutral California economy by 2045.

1.3.2 RD&D Landscape

The SoCalGas RD&D Program is a vital element of a much larger technology funding ecosystem that includes a variety of gas industry research consortia and numerous federal, state, and regional public agencies.

1.3.2.1 Research Consortia

The RD&D funding landscape includes a variety of gas industry research consortia that regularly collaborate with SoCalGas on RD&D projects. Typically consisting of multiple member organizations drawn from gas-industry utilities, vendors, suppliers, and equipment manufacturers, these consortia include:

- **NYSEARCH:** NYSEARCH is a collaborative research sub-organization managed by the Northeast Gas Association that serves 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.
- **Operations Technology Development (OTD):** OTD is a not-for-profit organization comprising 27 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.

- **Pipeline Research Council International (PRCI):** PRCI is 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.
- **Sustaining Membership Program (SMP):** SMP is a collaborative R&D program with two segments, Utilization and Operations. Its gas utility members support research projects focused on gas delivery, energy utilization, environmental science, and renewable energy. SMP develops the 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 Utilization Technology Development (UTD).
- **Utilization Technology Development (UTD):** UTD is a 20-member consortium of utilities in the United States and Canada, representing 47 million gas customers in North America. Its goal is to introduce new technologies that help gas consumers save money, reduce emissions, improve efficiencies, and optimize their gas use.

1.3.2.2 The California Energy Commission (CEC)

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, is 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. To date, the SoCalGas RD&D Program has co-funded numerous CEC-funded projects, 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 Program (NGRP)**
  CEC invests in natural-gas-related RD&D through its NGRP. The NGRP invests approximately $24 million per year in RD&D 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 with respect to integration of 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 electric vehicle and hydrogen refueling infrastructure, medium- and heavy-duty natural gas vehicles, biofuels, and associated workforce development.

1.3.2.3 California Air Resources Board (CARB)

The SoCalGas RD&D Program also collaborates regularly with CARB. 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 $PM_{2.5}$, meeting 8-hr ozone standards, further reducing GHG emissions, and ultimately reaching and surpassing carbon neutrality. CARB funds dozens of air quality and atmospheric science programs.[3] CARB's life cycle analysis models, such as the CA-GREET3.0 Model and Tier 1 Simplified Carbon Intensity Calculators,[4] are particularly important to the success of RD&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 2019-2020 fiscal year. CARB is allocating nearly $3.2 million for the following project categories:

- Studies that quantify the health impacts of air pollution exposure on vulnerable populations ($900,000)
- Improvements to indoor air quality (IAQ), energy efficiency, and greenhouse gas reductions through multifamily unit compartmentalization ($400,000)
- Health and air quality impacts of wildfire ($1,100,000)
- Incentivizing zero emission, high occupancy new mobility options ($700,000)
- Develop methodology for collection and analysis of perfluoroalkyl and polyfluoroalkyl substances (PFAS) ($25,000)
- Anti-displacement policy effectiveness ($25,000)
- Review of emerging technologies and methods for carbon sequestration ($25,000)

1.3.2.4 U.S. Department of Energy (DOE)

The RD&D Program also works closely with the DOE. The DOE manages hundreds of millions of dollars in energy sector funding. The agency targets its R&D efforts on developing and understanding basic

[3] CARB A - Z Index of All Top Level Programs / Topics can be accessed at: https://ww3.arb.ca.gov/html/all.htm
[4] CARB LCA Models are described at: https://ww3.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet_oldasof_61419.htm

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 demonstrations and commercialization efforts. DOE funding priorities also consider and match federal/nationwide or regional needs, but do not focus on RD&D needs and priorities that are specific to California or to SoCalGas customers or stakeholders.

The DOE R&D programs most relevant to SoCalGas's RD&D Program 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 high-value products from biomass or waste resources.
- **Fuel Cell Technologies Office (FCTO)** focuses on applied research, development, 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 (CCUS) 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 research and development 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, Lawrence Livermore National Laboratory, and the National Renewable Energy Laboratory. These organizations

develop advanced energy production and conversion technologies, many of which SoCalGas helps to advance from RD&D scale to full commercialization.

1.3.2.5 South Coast Air Quality Management District (SCAQMD)

SCAQMD supports RD&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 particulate matter. 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, and 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.

1.3.2.6 San Joaquin Valley Air Pollution Control District (SJVAPCD)

The San Joaquin Valley Air Pollution Control District (SJVAPCD) operates the Technology Advancement Program (TAP), which seeks to encourage and develop new emissions reduction technologies. The District implements the TAP with the goal of encouraging 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.

1.3.2.7 The SoCalGas RD&D Program

Within this rich funding ecosystem, the SoCalGas 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, business, 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. Because SoCalGas serves residential, business, 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 provide access to a rich base of potential demonstration sites within the region.

Importantly, because it enjoys greater flexibility than many other funding organizations, the RD&D Program often provides funding to innovative new products and technologies that federal, state, and regional agencies with slower funding cycles cannot fund. This flexibility enables the RD&D Program to supplement and complement the work of other organizations, stepping in to fill funding gaps at critical times when other organizations would be unable to act quickly.

1.3.3 Stakeholder Input

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 more 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.

Conversations with these stakeholders and SMEs are ongoing throughout the year, but in preparation for the 2021 funding allocations, RD&D Program staff also conducted a series of targeted interviews with more than 25 people from a variety of organizations in the first quarter of 2020.

Organizations Interviewed
California Energy Commission
Gas Technology Institute
U.S. Department of Energy
South Coast Air Quality Management District
San Joaquin Valley Air Pollution Control District
Northeast Gas Association
University of California, Davis
Pacific Gas & Electric
California Public Utilities Commission Energy Division
University of California, Irvine

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.

1.3.4 Annual Stakeholder Workshop

On April 24, 2020, the RD&D Program staff hosted an online workshop that was attended by 148 individuals from a wide variety of organizations, including:

AlvaradoSmith
ANGI Energy Systems LLC
Ballard
Bennett Pump
Buchalter
California Air Resources Board
California Energy Commission
California Public Utilities Commission
California State University, Fullerton
California State University, Los Angeles
Calpine Corporation
Clean Energy
Colonial Pipeline
DIY girls
Duarte Chamber of Commerce
e-Mission Control
Energy Solutions Center, Inc.
Fontana Chamber of Commerce
FuelCell Energy, Inc.
Gas Technology Institute
Global Energy Markets
Hispañas Organized for Political Equality
Imperial Valley Econ. Development Corporation
Inland Empire Economic Center
Irvine Ranch Water District
JM Energy Consulting
LA Conservation Corps
National Fuel Cell Research Center
National Renewable Energy Laboratory
Natural Gas Vehicles for America
Nel Hydrogen
Northeast Energy Efficiency Alliance
Northeast Gas Association
North Orange County Chamber
NW Natural
Oak Ridge National Laboratory
Opus 12
Orange County Hispanic Chamber of Commerce
Pacific Gas & Electric
Pacific Northwest National Laboratory
Packetized Energy
Pipeline Research Council International
Plug Power
ReactWell
Rinnai
Sandia National Laboratory
San Diego Gas & Electric
San Gabriel Valley Council of Governments
Sempra Utilities
South Coast Air Quality Management District
The Protect Our Communities Foundation
The Southern Company
Triple E Energy
University of California, Irvine
University of California, Riverside
University of Chicago

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. During the five-hour workshop, Mr. Meissner presented the following topics:

- Program Overview and Structure
- 2019 in Review
- 2020 Progress Report
- RD&D Research Plan Development
- Low Carbon Resources
- Clean Transportation

- Clean Generation
- Customer End-Use
- Gas Operations

At the end of each section of the presentation, Mr. Meissner accepted questions and comments. He and the RD&D Program staff addressed questions during the workshop. On April 30, 2020, a complete list of the 40 questions and comments received, as well as the responses and a link to the workshop recording, were emailed to all registered attendees. The link to the recording of the workshop was also posted to the SoCalGas RD&D website.[5] A complete record of the questions and comments from the workshop including answers provided by SoCalGas is included as Appendix B.

1.3.5 Incorporating Stakeholder Feedback

The SoCalGas RD&D Program staff acknowledge the considerable value of the input received from the CPUC and other stakeholders. This feedback was carefully reviewed and incorporated strategically into this Research Plan.

- Post-workshop comments provided by members of the CPUC Public Advocate's Office (Appendix C.6.b) requested a more detailed description of the budget allocation for each Program, as well as Program Administration. In an effort to provide greater transparency, the 2021 funding proposal (Section 1.6) was enhanced with additional detail. Further detail is provided for each sub-program under the section labelled 2021 Funding Allocation and Key Research Areas.
- Discussions with CPUC Energy Division staff resulted in a more detailed description of the Project Selection Process (Section 1.2.2).
- In pre-workshop interviews (Appendix A.2.a) and post-workshop comments from a community member and CEC staff (Appendix C.2.c; C.7.r; C.7.w), it became clear that the SoCalGas RD&D program should include Equity Engagement as a program component. These comments led to the formal addition of Equity to the Regulatory and Policy Drivers (Section 1.3.1) and Project Selection Process (Section 1.2.2).
- Post-workshop comments from a community member (Appendix C.2.c; C.2.d) and post-workshop interviews with CPUC staff and stakeholders with expertise in community outreach greatly informed the design of Equity Engagement Activities for 2020-2021 (Section 1.3.6).
- With guidance from CPUC staff, SoCalGas RD&D proposed modifications to the Sub-Program names (Section 1.5.1) 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. These modifications were presented during the annual workshop, and RD&D Program staff positive feedback from stakeholders (Appendix C.7.d).
- Multiple stakeholders suggested researching technologies that convert CO2 in useful products, including hand sanitizer (Appendix C.1.a) and value-added chemicals (Appendix C.4.b.iv). These suggestions will be considered under the Low GHG Chemical Processes Sub-Program under Carbon Capture & Utilization research.

[5] https://www.socalgas.com/smart-energy/research-and-development

1.3.6 Equity

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 environmental and social justice communities, especially to improve local air quality and public health.

Equity issues have been a consideration when the RD&D Program staff select projects to co-fund. At the annual workshop, Mr. Meissner provided several examples of past co-funded projects located in disadvantaged or low-income communities. Generally, these projects have focused on reducing GHG emissions, improving air quality, increasing the affordability of energy, and improving service reliability.

Location	Project Description
Brawley, California	In 2018-19, the RD&D program conducted three major demonstration projects at San Diego State University's satellite campus in Brawley, California. This campus services students from the surrounding farming community in the Imperial Valley, one of the nation's poorest regions. RD&D Program staff worked with the Imperial Valley Economic Development Corporation to identify local labor force resources to assist with these projects. These demonstration projects are available for the benefit of local STEM students.
Tulare, California	In 2019, the RD&D program worked closely with Saputo Cheese and Hyperlight Energy to secure CEC Food Production Investment Program (FPIP) funding for a solar thermal project at the Saputo cheese plant, located near disadvantage communities in Tulare, California.
Kern County Hwy-99 Corridor	In 2018-19, the RD&D program supported the biomass-energy projects targeted for the Kern County Hwy-99 corridor, adjacent to disadvantaged communities. When fully developed, these projects will provide jobs and educational opportunities for the local communities: 1) carbon-negative energy biomass gasification with carbon capture and sequestration (CCS) (Clean Energy Systems) and 2) a biomass gasification FEED study (Gas Technology Institute).
Mariposa, California	The RD&D program has been instrumental in supporting Cortus Energy's biomass gasification technology, which is at the center of the CEC-funded Mariposa Biomass Project. That project is expected to create 8-10 full time jobs at the facility with an average salary of $60,000 per year and 20-30 year - round jobs harvesting the biomass and transporting it to the facility.
Corona, California	In 2019, SoCalGas field-demonstrated a new high-efficiency drying technology in Corona, California.

Based on feedback received in outreach discussions and the annual workshop, RD&D Program Staff have added equity to the project selection criteria (Section 1.2.2) and committed to tracking and increasing program engagement in disadvantaged and low-income communities.

In support of these activities, RD&D Program staff will pursue the following activities in 2020-2021:

- Commit to long-term relationship-building with key representatives of disadvantaged and low-income communities throughout California.
- Work with the SoCalGas Regional Public Affairs team to identify and connect with contacts—such as Hispañas Organized for Political Equity (HOPE)—in disadvantaged and low-income communities and seek input on potential research needs.
- Prepare and present educational material to members of disadvantaged and low-income communities about the RD&D Program and its major programs and sub-programs and request feedback.
- Connect with regional California universities to identify researchers engaged with members of disadvantaged and low-income communities. Potential target universities include:
    - CSULA Center for Engagement, Service, and Public Good
    - UCLA Luskin Center
- Leverage existing connections within Air Districts, CARB, and CEC to identify promising contacts within disadvantaged and low-income communities.
- Establish metrics and goals to demonstrate progress, including presenting five non-technical RD&D presentations to California CBOs in 2020-2021.

For the year 2020, RD&D Program staff have so far conducted equity engagement outreach with CPUC staff experienced in helping utilities engage with CBOs, administration officials at CSULA, researchers at UCLA's Luskin Center for Innovation, and leadership of HOPE.

1.4 RD&D Key Initiatives

Regulatory and policy drivers, corporate policy and goals, and input from knowledgeable industry stakeholders have led the RD&D Program staff to establish three key RD&D Initiatives: 1) Hydrogen, 2) GHG Emissions Reduction, and 3) Safety and Reliability. These initiatives cut across program areas and sub-programs, providing the primary lens through which the RD&D Program staff selects projects and prioritizes research.

1.4.1 Hydrogen

Hydrogen, a zero-carbon fuel, has the potential to form the basis for multi-faceted, multi-benefit gas distribution and end-use scenarios that potentially change the way the existing SoCalGas infrastructure is utilized (Appendix A.1.a, d, f, g, A.2.e, A.3.b, k, l, m, A.6.h–m; Appendix B.2.b, e, B.3.a–f, B.5.a, e–g, B.6.a, f; Appendix C.7.g.iii, C.8.l–p, r–t, C.9.c, g, h, k, u). These involve:

- High-efficiency, modular, distributed renewable and low-carbon hydrogen generation
- Hydrogen blending and direct injection into the existing SoCalGas pipeline network
- New transmission and distribution pipeline operating requirements for transporting natural gas-hydrogen blends
- Point-source hydrogen extraction from natural gas-hydrogen blends in SoCalGas pipeline network

- Underground storage of natural gas-hydrogen blends
- Green hydrogen-based energy storage and use opportunities enabled by the SoCalGas pipeline system
- Revised appliance standards
- Fuel cell back-up and microgrid power generation for energy reliability and resilience
- Hydrogen-based power plants
- Hydrogen fueling stations

1.4.2 GHG Emissions Reduction

In accordance with state statutory goals and with SoCalGas' own internal goals, GHG emissions reduction is a critical element of the RD&D Research Plan. By supporting the development, conveyance, and distribution of new renewable energy resources, such as renewable methane and hydrogen from power-to-gas and artificial photosynthesis, SoCalGas' RD&D program will continue to support and achieve first-in-the-country gas utility advancements toward a decarbonized future (Appendix B B.6.b, Appendix C.5.b, C.5.e, C.5.g).

1.4.3 Safety and Reliability

Safety and reliability are critical elements across of all SoCalGas's existing operations and targeted developments. Research considered under the RD&D program ranges from development of new safety specifications and requirements for use of alternative fuels—such as hydrogen—to operational and equipment safety and reliability, geotechnical safety and resiliency, support for the development of microgrids and other reliability-oriented technologies, and management of hazards associated with climate change (Appendix A.2.b, A.6.i, A.8.g; Appendix B.e.i; Appendix C.3.d, C.5.a, d–f, C.9.b).

1.5 New in 2021

1.5.1 New Sub-Program Categories

As an element of the 2021 funding allocation and justification process, SoCalGas refreshed its sub-program 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 sub-programs and received positive feedback from stakeholders (Appendix C.7.d):

Program	2020 Sub-Programs	2021 Sub-Programs	Rationale
Low Carbon Resources	Renewable Gas Production	Renewable Gas Production	No Change
	Low Carbon Gas Conversion	Low Carbon Hydrogen Production	While the essence of this sub-program remains the same, emphasis is placed on hydrogen production and the associated low carbon processes for hydrogen production, whether through technological advances and innovations of existing natural gas reforming or pyrolysis pathways. (Appendix A.2.e, A.3.k, C.5.c)
	Carbon Capture & Use	Low GHG Chemical Processes	Broader and more general characterization of existing sub-program to encompass other processes and research areas, such as Carbon Capture, Utilization & Sequestration (CCUS) and Concentrated Solar Power (CSP) based process heating. (Appendix B.2.a, C.4.b)
Gas Operations	Environmental & Safety	Environmental & Safety	No changes were made. These sub-programs balance consistency and flexibility and served as the model for developing more durable sub-programs.
	Operations & Technology	Operations & Technology	
	System Design & Material	System Design & Material	
	System Inspection & Monitoring	System Inspection & Monitoring	

Program	2020 Sub-Programs	2021 Sub-Programs	Rationale
Clean Transportation	Near Zero Emissions Engines	On-Road	Focuses on On-Road applications but has the flexibility to advance different drivetrains and different fuels. (Appendix B.3.c, C.9.e)
	Compressed Natural Gas & Hybrid Vehicles		
	Off-Road (Locomotives, Construction & Marine)	Off-Road	Allow flexibility for future applications not enumerated previously.
	Compression & Refueling	Refueling Stations	Provides additional flexibility to address the entire set of technologies associated with fueling infrastructure, for example gas pre-cooling and dispenser design. (Appendix A.3.i, C.3.a)
	Fuel Systems & Storage	On-board Storage	More clearly identifies the project scope is focused on fuel storage on the vehicle. (Appendix C,3.c)
Clean Generation	DG-CHP-MicroCHP	Distributed Generation	Focuses on technologies for generating power, including engines, turbines, and fuel cells, while allowing for flexibility to identify new generating technologies. (Appendix C.7.g)
	Engines & Turbines		
	Fuel Cells		
	Waste Heat Recovery	Integration & Controls	Focuses on projects that develop and demonstrate the integration of DG equipment either with thermal applications for heat utilization (CHP) or with other generating and storage assets for resilient microgrid systems. (Appendix A.3.l, B.5.a, C.5.e)

Program	2020 Sub-Programs	2021 Sub-Programs	Rationale
Customer End-Use Applications	Zero Net Energy (ZNE) for Residential Buildings	Residential Appliances	Clearly defines scope of research while allowing flexibility to address key drivers, including GHG reduction through extreme efficiency improvements, reducing residential energy cost, and addressing increasingly stringent code requirements such as ZNE. (Appendix B.2.e, B.5.e, B.5.f, B.5.g, C.1.a, C.9.d, C.9.e)
	Appliance and Indoor Air Quality (IAQ)	Commercial Applications	Clarify the set of appliances, products, and applications under consideration. Commercial appliances are distinct in size and function from residential products and deserve a specific area of focus. IAQ is covered by the Advanced Innovation sub-program. (Appendix B.2.e, B.5.e, B.5.f, B.5.g, C.1.a, C.9.d, C.9.e)
	Commercial Cooking and Food Service	Commercial Food Service	Better aligns with industry standard naming practices.
	Solar Thermal Heating and Cooling	Advanced Innovation	While solar thermal technologies are important for reducing GHGs in thermal applications, the greater technology landscape is changing rapidly and this Sub-Program provides flexibility to address technologies that reduce GHGs, improve air quality, and increase affordability that are not addressed in other Sub-Programs. These include IAQ research and technologies such as Internet-of-Things (IoT), smart appliances and homes, building envelope improvements, and big data.
	Boilers and Process Heating	Industrial Process Heat	Clearly delineates the research as focused on the industrial market while providing flexibility to address various technologies that provide process heat. (Appendix B.1.l, C.9.d)

1.6 Proposed 2021 Funding

The total authorized funding for the RD&D program for 2021 was set by the 2019 General Rate Case (GRC) decision, which established the authorized funding for test year 2019 and escalation/attrition rates for each subsequent year in SoCalGas' rate case cycle. The total authorized funding for 2021 is $16,180,000. This section provides additional detail for the budget components (see also Appendix C.6.b).

The Program Administration forecast for 2021 is outlined below. The Compliance & Reporting and Program Planning & Workshop line items estimate costs associated with requirements for the RD&D program set forth in the 2019 GRC decision which include producing the Annual Report, hosting a public workshop, and developing an Annual Research Plan. Other budget items—added or enhanced based on input from stakeholders (Appendices A and C)—include:

- Stakeholders suggested that SoCalGas RD&D Program staff engage in more education and outreach to share the results of research activities with the research community and general public (Appendix A.7.d). Budget is allocated to support a number of webinars and other public presentations and to improve the RD&D website.
- Stakeholders suggested that SoCalGas RD&D Program staff develop a framework to increase equity engagement, particularly with disadvantaged communities (DACs) and CBOs (Appendix A.2.a and Appendix C.2.c, C.7.w). Budget is allocated to support those efforts, including general audience presentations, meetings, research, and program design.

Program Administration Budget Items	2021 Forecast
Management Labor	$674,282
Administrative Labor	$260,718
Compliance & Reporting	$125,000
Program Planning & Workshop	$200,000
Education & Outreach Activities	$10,000
Equity Engagement Program	$100,000
Database & Website Improvements	$150,000
Total	**$1,520,000**

The remaining authorized budget (i.e., the total authorized funding less the management and administration forecast) is allocated across the sub-programs. First, each subprogram identified committed funds for 2021. These are funds that will be spent in 2021 with a high degree of certainty.

Next, each sub-program identified funds for projects that are under development for 2021. Sub-program personnel identified key research areas of interest for 2021. This funding is allocated to support projects in these key research areas for which some uncertainty in timing or budget remains, i.e., certain components such as research partner, testing location, co-funding source, or timeline have not been determined. The key research areas are examples of research interest that could be funded if the appropriate projects are developed. Funds may also be redirected to new research areas that arise during the plan year.

Programs	2021 Program Level Funding	Sub-Programs	2021 Sub-Program Level Funding
Low Carbon Resources	$ 5,424,200	Renewable Gas Production	$ 1,500,000
		Low Carbon Hydrogen Production	$ 2,924,200
		Low GHG Chemical Processes	$ 1,000,000
Gas Operations	$ 3,518,400	Environmental & Safety	$ 652,311
		Operations Technology	$ 285,553
		System Design & Materials	$ 1,743,227
		System Inspection & Monitoring	$ 837,309
Clean Transportation	$ 2,052,400	On-Road	$ 935,424
		Off-Road	$ 809,600
		Refueling Stations	$ 134,582
		Onboard Storage	$ 172,794
Clean Generation	$ 1,612,600	Integration & Controls	$ 806,300
		Distributed Generation	$ 806,300
Customer End-Use Applications	$ 2,052,400	Commercial Food Service	$ 157,600
		Residential Appliances	$ 900,600
		Commercial Applications	$ 235,715
		Industrial Process Heat	$ 620,570
		Advanced Innovation	$ 137,915
Program Administration	$ 1,520,000	Program Administration	$ 1,520,000
Total:	**$ 16,180,000**		

RD&D funds are managed under a one-way balancing account treatment. As such, unspent funds from 2020 will be rolled over to 2021 and will be allocated to the sub-programs on a pro-rata basis.

2.0 Low Carbon Resources

2.1 Overview, Goals, and Structure

The primary goal of the Low Carbon Resources program area is to decarbonize the gas supply while maintaining its affordability and reliability. To accomplish this goal, Low Carbon Resources program staff members develop, promote, and advance new technologies aimed at increasing and expanding the production of RNG and low-cost/low-carbon hydrogen to displace conventionally sourced pipeline natural gas, while limiting GHG emissions. RD&D personnel in this program area focus their efforts to pursue the following four goals:

- Increasing the availability of RNG and low-cost/low-carbon hydrogen
- Facilitating the adoption of large-scale decarbonization solutions using cost-effective technologies that can be widely deployed
- Diversifying renewable gas production sources to encompass a broad variety of feedstocks and pathways
- Identifying, developing, and advancing innovative solutions and technologies that reduce GHG emissions as well as reliance on fossil-sourced natural gas

In 2021, the Low Carbon Resources program will be composed of three sub-programs: 1) Renewable Gas Production, 2) Low Carbon Hydrogen Production, and 3) Low GHG Chemical Processes.

2.2 Renewable Gas Production

2.2.1 Sub-Program Overview

This sub-program focuses on the safe, reliable, and cost-effective production of renewable and low-carbon gaseous fuels—specifically RNG and hydrogen. Areas of focus include, but are not limited to, biomass processing and conversion, hydrogen production from renewable sources, and methanation.

2.2.2 Sub-Program Benefits

Low Carbon Resources Program: Renewable Gas Production Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Renewable gas (methane and hydrogen) production provides valuable environmental benefits by displacing fossil-sourced hydrocarbons, thereby reducing, mitigating or eliminating GHG emissions from fossil-fuel derived CO2 and CH4 emissions and providing, in-turn, substantial environmental (air and water) benefits and contributing to the fight against climate change.
Reliability	Renewable gas production can also enhance the reliability of the gas supply, while helping decarbonize it, since SoCalGas has extensive in-state, close-to-market resources that can be greatly leveraged, such as surplus of renewables, large dairy, and agricultural industries.

Low Carbon Resources Program: Renewable Gas Production Sub-Program	
Benefits	**Explanation**
Operational Efficiencies	By utilizing otherwise curtailable power through producing green hydrogen using water electrolysis, for example, renewable gas production can improve the operational efficiencies of the electric grid by smoothing out the power supply/demand curve and creating a market for otherwise curtailable wind and solar power. This will enable greater market penetration of renewable energy resources, such as wind, solar, and biogas. Other operational efficiencies of note apply to farmers, many of whom reside in low-income and disadvantaged communities, where bio-digester technology for the production of RNG improves the farmers' ability to manage their waste and emissions more effectively while creating cost savings and improving the operational efficiencies of their businesses.

2.2.3 2021 Funding Allocation and Key Research Areas

Low Carbon Resources Program	
Renewable Gas Production Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 50,000
Funds for Projects Under Development for 2021	$ 1,450,000
Total Sub-Program Funding for 2021	$ 1,500,000
Sub-Program Percentage of Program Funding	28%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Renewable Hydrogen Production via Direct Water-Splitting**
  Direct, high-efficiency, sunlight/photon-driven water splitting into hydrogen and oxygen is an important area of research with tremendous potential to refine the conventional, multi-step process of producing green hydrogen by coupling renewable electric power with water electrolysis into a single-step process. By decoupling green hydrogen production from the power grid, this technology would also eliminate intrinsic power system conversion and transmission losses, costly transmission system upgrades, and competition with electricity end-users. Relevant regulatory and policy drivers include:
  - AB 8
  - LCFS
  - SB 100
  - AB 32 – Reducing CO2 emissions
  - AB 3232 – Building Decarbonization
- **Area 2: Renewable Methane Production from Biogenic CO2 with Methanation**
  Renewable methane production from biogenic CO2 with methanation, either via conventional

thermocatalytic methanation, an electrocatalytic process, or the use of biological methanogens, is a key area of research that can be broadly deployed to capture and convert biogenic CO2 emissions from bio-digesters, ethanol plants, landfills, and biomass gasifiers into renewable natural gas (RNG). Thus, methanation technologies can expand the availability of renewable gas and, thereby, displace fossil-sourced gas, reduce net emissions and improve air quality. Moreover, the RNG produced through methanation has approximately triple the energy density of hydrogen (~990 Btu/scf vs. 330 Btu/scf). Relevant regulations and policy drivers include:

  - SB 1383
  - CPUC ESJ Action Plan
  - AB 617
  - LCFS

- **Area 3: Hydrogen Separation/Purification from a Blended Natural Gas Stream**
  The natural gas utilities' pipeline system is composed of thousands of miles of pipeline that can be highly and efficiently leveraged to store very large quantities of hydrogen (TWh scale) for long durations and seasonal storage, unlike batteries' diurnal storage capacity. New technologies are being developed to separate hydrogen from a blended natural gas stream at the source (fueling station, etc.). By enabling end-users to take advantage of the widely available and easily accessible natural gas system, these technologies can drastically cut hydrogen utilization costs, hence promoting and facilitating the adoption of zero- and low-carbon hydrogen fuel. Relevant regulations and policy drivers include:

  - AB 8
  - EO B48-18
  - LCFS

2.3 Low Carbon Hydrogen Production

2.3.1 Sub-Program Overview

This sub-program focuses on the production of low carbon hydrogen using various methane feedstocks. Areas of focus include, but are not limited to, methane pyrolysis and advanced steam methane reforming (SMR) technologies.

2.3.2 Sub-Program Benefits

Low Carbon Resources Program: Low Carbon Hydrogen Production Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Low carbon hydrogen production provides valuable environmental benefits by displacing fossil-sourced hydrocarbons, thereby reducing, mitigating or eliminating GHG emissions from fossil-fuel derived CO2 and CH4 emissions and providing, in-turn, substantial environmental (air and water) benefits and contributing to the fight against climate change.

Low Carbon Resources Program: Low Carbon Hydrogen Production Sub-Program	
Benefits	**Explanation**
Reliability	Low carbon, distributed hydrogen production also helps improve the reliability of the hydrogen supply at fueling stations, by allowing for self-generate on-site, low carbon hydrogen, and operating the fueling station with minimal interruption due to supply limitations.

2.3.3 2021 Funding Allocation and Key Research Areas

Low Carbon Resources Program	
Low Carbon Hydrogen Production Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 1,567,000
Funds for Projects Under Development for 2021	$ 1,357,200
Total Sub-Program Funding for 2021	$ 2,924,200
Sub-Program Percentage of Program Funding	54%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Distributed, Low Carbon Hydrogen Production**
  Distributed hydrogen production via small-scale SMR, using natural gas feedstock (renewable or conventional) can help boost hydrogen adoption as fuel by allowing fueling station to self-generate the hydrogen they need. This paradigm shift in hydrogen production from a centralized, very large-scale SMR plants, which have historically supported refinery operation, to small/distributed SMR plants/fueling stations capable of simultaneously producing and dispensing their own hydrogen will most assuredly help expand the hydrogen market by increasing reliability, alleviating supply shortages and reducing dispensed hydrogen cost by cutting out scheduling and transportation costs. Relevant regulations and policy drivers include:
  - AB 8
  - EO B48-18
  - LCFS
- **Area 2: Hydrogen Production Using Advanced, Distributed SMR**
  SoCalGas is exploring different SMR technologies, including advanced catalytic non-thermal plasma (CNTP) and meso- and micro-channel SMR reactors (STARS). SMR technology has progressed greatly in recent years with the development and manufacturing (3-D printing) of new, high-efficiency, low-cost, modular, combustion-free, solar- and/or induction heat-driven, steam-methane reforming technology for distributed hydrogen production called STARS. STARS technology has now reached a high TRL and is ready for field-demonstration and deployment to support distributed hydrogen production. Relevant regulations and policy drivers include:
  - AB 8
  - EO B48-18

- LCFS
- Clean Air Act

- **Area 3: Methane Pyrolysis**
  SoCalGas is investigating multiple methane pyrolysis pathways. This technology has to potential to reduce the cost of large-scale hydrogen generation while mitigating carbon emissions by co-producing hydrogen and solid carbon for a variety of applications (cement additives, carbon nanotubes, etc.). Relevant regulations and policy drivers include:
  - EO B-55-18
  - AB 32 – Reducing CO2 emissions
  - AB 3232 – Building Decarbonization

2.4 Low GHG Chemical Processes

2.4.1 Sub-Program Overview

This sub-program helps design, develop, and deploy technologies that can minimize reliance on natural gas combustion, as well as technologies for the capture of GHG emissions and their conversion into valuable chemicals. Areas of focus include, but are not limited to, application of concentrated solar power technology (CSP) to industrial processes, Carbon Capture and Utilization (CCU), and CCS.

2.4.2 Sub-Program Benefits

Low Carbon Resources Program: Low GHG Chemical Process Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Low GHG Chemical Processes often use direct solar thermal energy and/or high-efficiency induction heating that can be powered by wind or solar resources. Low GHG Chemical Processes may include Carbon Capture Utilization and Sequestration (CCUS) systems that are vital in the fight against climate change. Low GHG Chemical Processes achieve extremely high/record levels of energy efficiency by using designs that feature very tight thermal integration. In addition to environmental and sustainability benefits, these energy highly efficient systems provide valuable cost savings benefits for residential, institutional, commercial, and industrial customers.
Safety	Low GHG Chemical Processes often use modular, microchannel reactors that feature lower reactant concentrations and smaller amounts of thermal mass, making them inherently safer than conventional chemical processes systems.

2.4.3 2021 Funding Allocation and Key Research Areas

Low Carbon Resources Program	
Low GHG Chemical Processes Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 0
Funds for Projects Under Development for 2021	$ 1,000,000
Total Sub-Program Funding for 2021	$ 1,000,000
Sub-Program Percentage of Program Funding	18%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Concentrated Solar Power (CSP) Technology for Industrial Applications**
  CSP technology can significantly lower a facility's carbon footprint by minimizing its reliance on natural gas combustion; thereby reducing air emissions and improving air quality. Additionally, this technology can be seamlessly coupled with biomass conversion processes to reduce the carbon intensity of biomass-derived renewable gas. Relevant regulations and policy drivers include:
    - SB 1383
    - CPUC ESJ Action Plan
    - Clean Air Act
- **Area 2: Carbon Capture and Utilization (CCU)**
  CCU explores technologies and processes related to carbon negative cycles, carbon capture sorbents for biogas upgrading, and carbon conversion into valuable chemicals such a methanol, DME, concrete, etc. As a result, CCU prevents carbon emissions to the atmosphere and improves air quality. Relevant regulations and policy drivers include:
    - AB 32 – Reducing CO2 emissions
    - SB 100
    - EO B-55-18
- **Area 3: Carbon Capture and Sequestration (CCS)**
  SoCalGas is investigating 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 sequestrate CO2. Studies by the Intergovernmental Panel on Climate Change[6] (IPCC) and the California Council on Science and Technology (CCST) have shown that CCS has the potential to reduce carbon emissions by billions of metric tons and may be an integral part of meeting California's climate goals in 2050[7]. CCS allows for existing fossil fuel resources, such as natural gas, to be used in a way that is much lower in carbon emissions than their use without CCS. Due to the potential importance of CCS in

[6] 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.
[7] CCST, 2011, California's Energy Future: The View to 2050.

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[8]. Studies have concluded that there is sufficient pore space available in California to inject tens of billions of metric tons of CO2[9]. CCS is already being deployed to sequester carbon emission from large-scale SMR and improve the carbon intensity of natural-gas derived hydrogen (blue vs. gray hydrogen). Synergies can also exist between CCS technologies and various renewable gas production pathways, such as biomass gasification. Projects in this research area aim at identifying and demonstrating the most economically viable CCS pathways, including co-generation of hydrogen and electricity. Relevant regulations and policy drivers include:

- AB 32 – Reducing CO2 emissions
- SB 100
- EO B-55-18
- LCFS

[8] Assembly Bill 32, The Global Warming Solutions Act of 2006, AB 32, Statutes of 2006, Chapter 488

[9] National Energy Technology Laboratory, U.S. Department of Energy, Carbon Storage Atlas: Fifth Edition, September 2015, page: 110.

2.5 Visual Summary of Proposed 2021 Funding Allocation

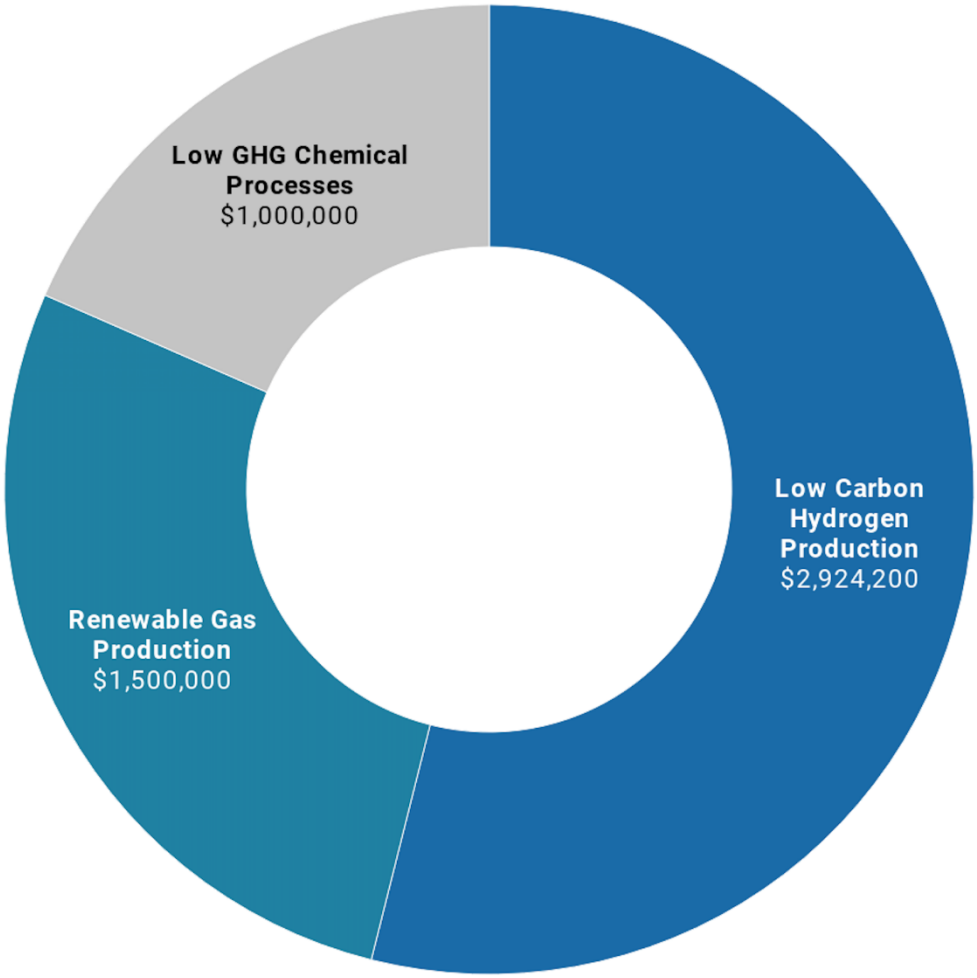


Figure 1: Low Carbon Resources 2021 sub-program budget breakdown.

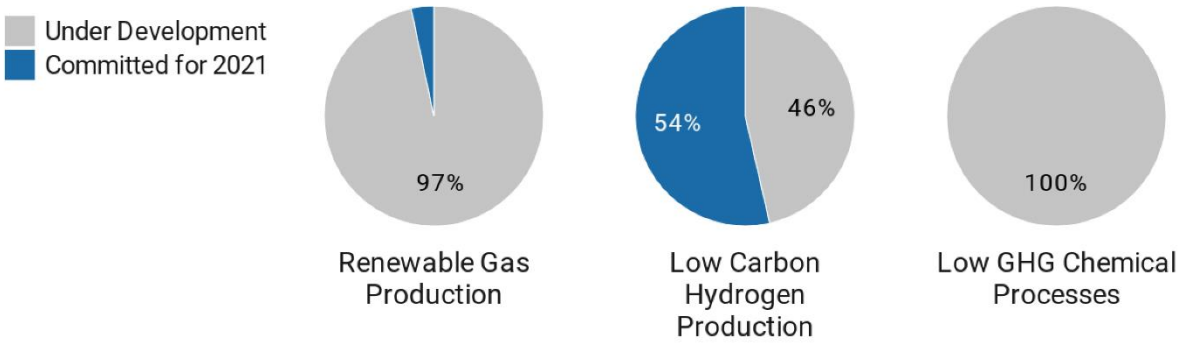


Figure 2: Low Carbon Resources sub-programs split between committed 2021 funds and funds under development.

3.0 Gas Operations

3.1 Overview, Goals, and Structure

The Gas Operations RD&D program 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.

Gas Operations is composed of four sub-programs: 1) Environmental & Safety, 2) Operations Technology, 3) System Design & Materials, and 4) System Inspection & Monitoring.

3.2 Environmental & Safety

3.2.1 Sub-Program Overview

This sub-program 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 reduce air emissions and environmental impacts of the system infrastructure. Safety projects are concerned with protecting the pipeline from intentional and unintentional damage and with the safety of the general public and company employees or contractors when in the vicinity of or working on or around the pipeline system and infrastructure.

3.2.2 Sub-Program Benefits

Gas Operations Program: Environmental & Safety Sub-Program	
Benefits	**Explanation**
Environmental	Research projects are aimed at reducing the environmental impact of the pipeline system and system operations, including improving air quality by reducing emissions, such as post-combustion criteria pollutants. Projects in this sub-program also seek to develop technologies and best practices for reducing GHG emissions and to mitigate the impacts of the gas system on climate change.
Safety	Projects in this sub-program seek to develop advanced systems to identify and mitigate threats to the pipeline system, protect pipelines from intentional and unintentional damage, and focus on various other aspects related to the safety of the general public, company employees, and contractors working on or around the pipeline and system facilities.
Reliability	System reliability benefits are often coupled with research projects related to pipeline safety as pipeline safety incidents are the main contributor to unplanned system outages. Research projects aimed at improving system integrity and reducing system damages result in a reduction in the number of system outages.

Gas Operations Program: Environmental & Safety Sub-Program	
Benefits	**Explanation**
Operational Efficiencies	Research projects generally consider operational efficiency as a driver when identifying and comparing technologies. Company involvement in technology, methods development and refinement of practices synergistically drives solutions that contribute to operational efficiency and avoidance of alternative higher-cost options.

3.2.3 2021 Funding Allocation and Key Research Areas

Gas Operations Program	
Environmental & Safety Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 595,425
Funds for Projects Under Development for 2021	$ 56,886
Total Sub-Program Funding for 2021	$ 652,311
Sub-Program Percentage of Program Funding	19%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: System Emissions**
  Advanced technologies are being developed to address post-combustion criteria air pollutant emissions and fugitive GHG emissions. This effort includes projects that monitor, detect, quantify, or reduce emissions. Relevant regulations and policy drivers include:
  - Clean Air Act
  - Various Air Quality Standards (federal and state)
  - National Environmental Protection Act
  - AB 32 – Reducing CO2 emissions
  - U.S. EPA Methane Challenge Program
  - CARB Oil and Gas Rule

  Area 2: Environment
  Environmental projects focus on developing methods to prevent or mitigate contaminated water run-off or hazardous waste and preserve conservation of plants and endangered species during pipeline construction and repair within environmentally sensitive areas. This effort includes projects related to the impact of ground subsidence in the San Joaquin Valley caused by drought and compressor emissions. Relevant regulations and policy drivers include:
  - Endangered Species Act
  - Clean Water Act
  - DOT 49 CFR Part 172.704

- **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. Relevant regulations and policy drivers include:

  - Cal OSHA
  - DOT 49 CFR Part 192
  - CPUC General Order 112F
  - Dig Alert – 811

3.3 Operations Technology

3.3.1 Sub-Program Overview

This sub-program supports technologies that improve efficiency of construction; operation, maintenance, and rehabilitation of gas pipelines; and development of systems that facilitate continued safe and reliable service, and advancements in technologies related to human factors and ergonomics.

3.3.2 Sub-Program Benefits

Gas Operations Program: Operations Technology Sub-Program	
Benefits	**Explanation**
Reliability	Projects in this sub-program develop methods and technologies for pipeline construction, alteration, and repair. Research projects seek to minimize impacts to customers by avoiding service interruptions along with extending the service life of the pipeline infrastructure.
Safety	Projects in this sub-program develop advanced operations technologies, tools, and equipment to facilitate pipeline operation, maintenance, and repair activities while maintaining worker and public safety.
Operational Efficiencies	Projects in this sub-program develop more efficient construction, maintenance, and repair solutions. They can also develop advanced materials and methods to quickly restore pipelines to service while maintaining system integrity, avoiding significant time and expense associated with installing a new pipeline infrastructure.

Gas Operations Program: Operations Technology Sub-Program	
Benefits	**Explanation**
Environmental	Projects in this sub-program can reduce GHG emissions by identifying alternative and new technologies for operational activities to reduce vented and fugitive emissions. They can also develop advanced technologies to support pipeline construction, maintenance, and repair activities in environmentally sensitive areas and minimize the environmental/carbon footprint/societal impact of construction activities, such as paving, roadways, and traffic flow.

3.3.3 2021 Funding Allocation and Key Research Areas

Gas Operations Program	
Operations Technology Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 282,347
Funds for Projects Under Development for 2021	$ 3,206
Total Sub-Program Funding for 2021	$ 285,553
Sub-Program Percentage of Program Funding	8%

Based on input received during outreach activities, in 2021, this sub-program will target the following three 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, such as steel pipe 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. Relevant regulations and policy drivers include:
    - CPUC General Order 112F
    - DOT 49 CFR Part 192
- **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 to help address the 21% of excavation damages caused by insufficient or inaccurate locating practices. 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—such as congested downtowns or urban canyons—where traditional methods and technology are inadequate. Relevant regulations and policy drivers include:

  - CPUC General Order 112F
  - DOT 49 CFR Part 192

- **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. Relevant regulations and policy drivers include:

  - CPUC General Order 112F
  - DOT 49 CFR Part 192

3.4 System Design & Materials

3.4.1 Sub-Program Overview

The objectives of this sub-program 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 an asset. 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 natural gas quality from non-traditional sources (biogas and hydrogen-blend).

3.4.2 Sub-Program Benefits

Gas Operations Program: System Design & Materials Sub-Program	
Benefits	**Explanation**
Reliability	Research in this sub-program facilitates development of advanced techniques and models to support reliable system designs, including designing for system integrity, maintainability, and compatibility with modern materials and existing infrastructure. System reliability is facilitated by the advancement in pipeline materials, which, in turn, enables improved short- and long-term pipeline system performance, such as through reducing the incidence of failure or leakage of the pipeline system. Research related to gas composition and quality supports system reliability through establishing critical set points and validation of system compatibility. Research projects address reliability impacts on the pipeline infrastructure due to gas composition changes, such as from introducing renewable natural gas and hydrogen.

Gas Operations Program: System Design & Materials Sub-Program	
Benefits	**Explanation**
Safety	Research projects in this sub-program support proper system design and material selection, which reduces the incidence of failure or leakage of pipeline infrastructure and the associated dangers. Projects in this sub-program can also improve understanding of the implications of potential risk factors, such as stresses due to internal gas pressure, construction procedures, and environmental factors (corrosive and geohazards). These projects often provide analytics of materials that address these risks and enable improvements in the initial design that can mitigate the risks prior to installation, thereby contributing to a more safe and reliable system.
Operational Efficiencies	Projects in this sub-program support operational efficiencies through advancements in system design and materials that improve system performance and, thereby, reduce reliance on field activities such as conventional inspections, maintenance, and repair.
Environmental	Projects in this sub-program support environmental benefits through the analysis of materials that enable the pipeline system to accept hydrogen or renewable gas. This process ultimately reduces the carbon footprint of the natural gas system and minimizes downstream environmental impacts. These projects also reduce GHG emissions through assessment of the impacts of climate change on the gas system and development of system designs and materials that can mitigate those impacts.

3.4.3 2021 Funding Allocation and Key Research Areas

Gas Operations Program	
System Design & Materials Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 1,354,915
Funds for Projects Under Development for 2021	$ 388,312
Total Sub-Program Funding for 2021	$ 1,743,227
Sub-Program Percentage of Program Funding	50%

Based on input received during outreach activities, in 2021, this sub-program will target the following three 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. Research projects in this area will seek to identify trace constituents and support establishment of upper limits for accepting RNG. Hydrogen-related research projects would identify barriers that could

prevent the introduction and blending of 10%-20% hydrogen into existing pipeline infrastructure. Additionally, projects in this area could develop cost-effective, miniature online VOC and siloxane analyzers that have the detection levels and accuracies of laboratory equipment. Relevant regulations and policy drivers include:

- SB 1383
- Biomethane OIR Phase 3 (R.13-02-008)
- AB 32 – Reducing CO2 emissions
- AB 1900

- **Area 2: System Design**
  Improved understanding of the implications of potential risk factors, such as stresses due to internal gas pressure, construction procedures, and environmental factors (corrosive and geohazards), along with analytics of materials that mitigate these risks enable improvements in the initial design that can mitigate the risks prior to installation, thereby contributing to a more safe and reliable system. 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. Relevant regulations and policy drivers include:
  - CPUC General Order 112F
  - DOT 49 CFR Part 192
- **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 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. Relevant regulations and policy drivers include:
  - CPUC General Order 112F
  - DOT 49 CFR Part 192

3.5 System Inspection & Monitoring

3.5.1 Sub-Program Overview

The objectives for this sub-program include developing technologies and methods for inspection, monitoring, and testing of pipelines and pipeline components to assess the condition and performance of the assets. The goal is to improve system performance, reliability, safety, and operational efficiencies. Projects in this sub-program area often leverage artificial intelligence, machine learning, and preventive and predictive maintenance technologies, including data analytic models, IoT, and data lakes.

3.5.2 Sub-Program Benefits

Gas Operations Program: System Inspection & Monitoring Sub-Program	
Benefits	**Explanation**
Reliability	Projects in this sub-program seek to improve system monitoring and inspection to help identify and mitigate pipeline integrity threats. Successful projects would result in both the prevention of and a reduction in the number of system outages, thereby improving system reliability.
Safety	Projects in this sub-program would improve system monitoring and inspection, enabling earlier detection of threats to system safety and reliability. Safety improvement are achieved through preventing or reducing the incidence of system ruptures, damages, or leaks, improving response times, and deploying preventative maintenance measures.
Environmental	System inspection and monitoring can prevent incidents and improve responsiveness to environmental threats.
Operational Efficiencies	Research projects funded under this sub-program consider operational efficiency as a driver when identifying and comparing technologies and practices that leverage automation of data gathering and analytics to advance pipeline safety and regulatory compliance.

3.5.3 2021 Funding Allocation and Key Research Areas

Gas Operations Program	
System Inspection & Monitoring Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 642,713
Funds for Projects Under Development for 2021	$ 194,596
Total Sub-Program Funding for 2021	$ 837,309
Sub-Program Percentage of Program Funding	24%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Inline Pipeline Inspection and Monitoring**
  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 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. Relevant regulations and policy drivers include:
    - CPUC General Order 112F
    - DOT 49 CFR Part 192
- **Area 2: Remote Pipeline Inspection and Monitoring**
  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. Relevant regulations and policy drivers include:
    - CPUC General Order 112F
    - DOT 49 CFR Part 192
    - CARB Oil and Gas Rule
    - AB 32 – Reducing CO2 emissions
    - Clean Air Act of 1963
- **Area 3: Geohazard Threats 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. Relevant regulations and policy drivers include:
    - CPUC General Order 112F
    - DOT 49 CFR Part 192

3.6 Visual Summary of Proposed 2021 Funding Allocation

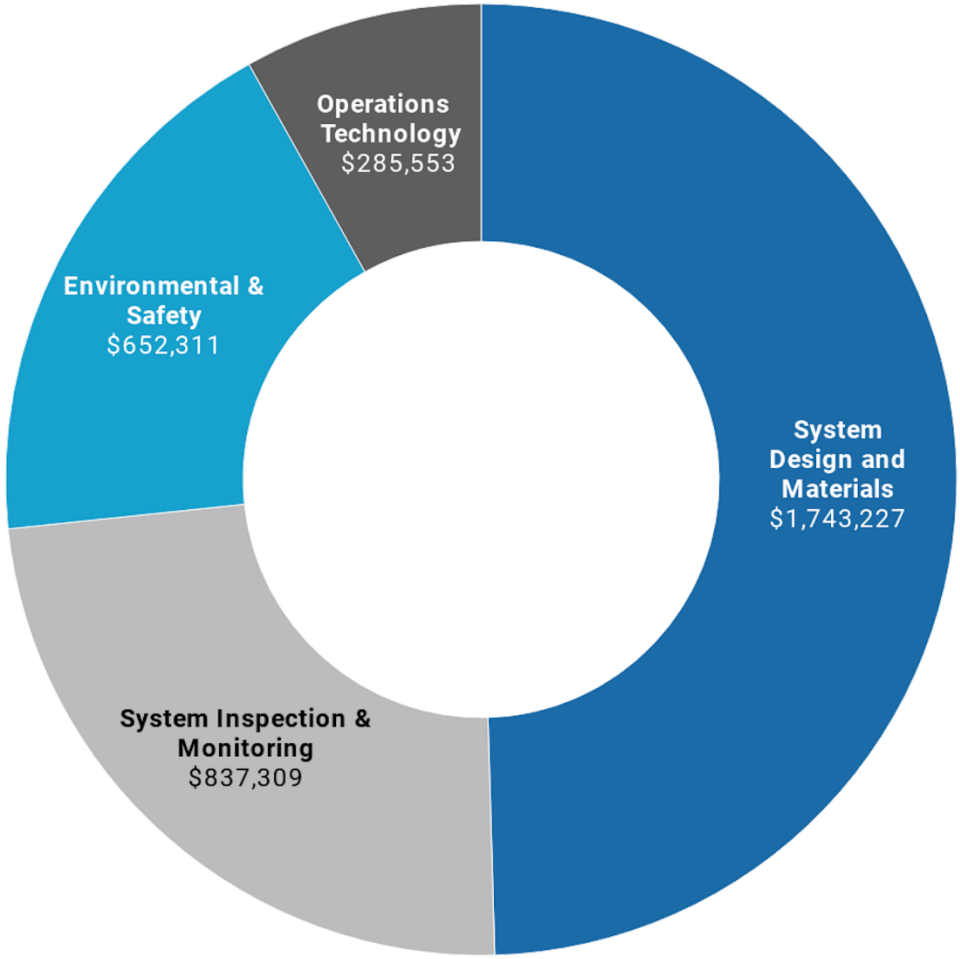


Figure 3: Gas Operations 2021 sub-program budget breakdown.

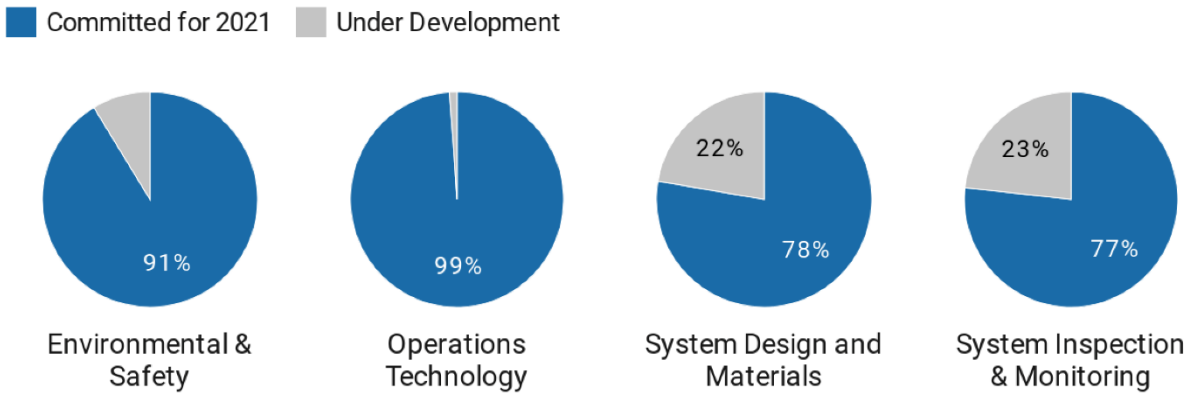


Figure 4: Gas Operations sub-program split between committed 2021 funds and funds under development.

4.0 Clean Transportation

4.1 Overview, Goals, and Structure

The Clean Transportation sub-program supports activities that minimize environmental impacts related to the transportation sector through the development of low-carbon fuels, zero- and near-zero-emissions drivetrains, fueling infrastructure, and on-board storage technologies. Clean Transportation is composed of four sub-programs: 1) On-Road, 2) Off-Road, 3) Refueling Stations, and 4) Onboard Storage.

4.2 On-Road

4.2.1 Sub-Program Overview

This sub-program targets emissions reductions from medium- and heavy-duty on-road vehicles. The focus is on-road transportation technologies using natural gas, RNG, and hydrogen.

4.2.2 Sub-Program Benefits

Clean Transportation Program: On-Road Sub-Program	
Benefits	**Explanation**
Environmental Benefits	On-Road near-zero emission engines using CNG and RNG emit 90% less NOx than conventional diesel engines and zero emission hydrogen fuel cell technology utilize electric drive trains that emit zero NOx and GHG to provide environmental benefits. Using pipeline delivery can increase environmental benefits by minimizing the use of over-the-road trucks that emit NOx and GHG for fuel delivery.
Operational Efficiencies	Compressed gases, such as CNG and RNG and production of hydrogen via SMR, can take advantage of existing natural gas pipelines to provide transportation fuel to fleets. Delivering fuel through pipeline versus conventional methods improves operational efficiency by consistently delivering fuel to stations without relying on delivery schedules.

4.2.3 2021 Funding Allocation and Key Research Areas

Clean Transportation Program	
On-Road Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 935,424
Funds for Projects Under Development for 2021	$ 0
Total Sub-Program Funding for 2021	$ 935,424
Sub-Program Percentage of Program Funding	46%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Near-Zero Emission CNG Engine Development**
  Research advanced near-zero emission CNG engine technology to increase engine performance, efficiency, and CNG hybrid drivetrains. Current near-zero emission CNG engines emit 90% lower NOx than its diesel counterpart and are commercially available. Advancing engine performance, efficiency and CNG hybrid drivetrains will aim to bring the technology on par with diesel performance and emissions benefits closer to zero-emission vehicles. Relevant regulations and policy drivers include:
    - AB 32 – Reducing CO2 emissions
    - EO B-32-15
    - LCFS
    - CARB Implementation Plan
- **Area 2: Hydrogen Fuel Cell Vehicles Development**
  Research in advanced hydrogen fuel cell vehicles (HCFV) for medium- and heavy-duty freight and goods movement. Medium- and heavy-duty trucks account for over 50% of mobile source emissions in the South Coast Air Basin. HFCV's offer zero-emission benefits and the power and torque of battery electric vehicles, without compromising weight and refueling time. Medium- and heavy-duty HFCV development will help transit and the freight and goods movement reduce emissions with zero tailpipe emission. Relevant regulations and policy drivers include:
    - AB 32 – Reducing CO2 emissions
    - EO B-32-15
    - LCFS
    - CARB Implementation Plan
    - SB 1275
- **Area 3: Zero and Near-Zero Emission Vehicle Demonstrations**
  Demonstrating zero and near-zero emission vehicles is an important part of the research process. Demonstrating advanced vehicle technologies will help uncover and address issues during real world duty cycles. This will help improve technologies and assist in the adoption of zero and near-zero emission vehicles. Demonstrations will also assist in identifying workforce development and maintenance schedules to help reduce challenges and hurdles of adopting new technology. Relevant regulations and policy drivers include:
    - AB 32 – Reducing CO2 emissions
    - EO B-32-15
    - LCFS
    - CARB Implementation Plan
    - SB 1275

4.3 Off-Road

4.3.1 Sub-Program Overview

This sub-program targets emissions reductions from off-road vehicles such as rail, ocean-going vessels, commercial harbor craft, and cargo handling equipment, where gaseous fuels can reduce emissions. The sub-program focuses on developing zero- and near-zero emission off-road transportation solutions using natural gas, RNG, and hydrogen.

4.3.2 Sub-Program Benefits

Clean Transportation Program: Off-Road Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Off-Road near-zero emission engines using CNG and RNG emit 90% less NOx than conventional diesel engines and zero emission hydrogen fuel cell technology utilize electric drive trains that emit zero NOx and GHG to provide environmental benefits. Using pipeline delivery can increase environmental benefits by minimizing the use of over-the-road trucks or rail that emit NOx and GHG for fuel delivery.
Operational Efficiencies	Compressed gases, such as CNG and RNG and production of hydrogen via SMR, can take advantage of existing natural gas pipelines to provide transportation fuel to fleets. Delivering fuel through pipeline versus conventional fuel improves operational efficiency by consistently delivering fuel to stations without relying on delivery schedules.

4.3.3 2021 Funding Allocation and Key Research Areas

Clean Transportation Program	
Off-Road Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 809,600
Funds for Projects Under Development for 2021	$ 0
Total Sub-Program Funding for 2021	$ 809,600
Sub-Program Percentage of Program Funding	39%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Zero and Near-Zero Emission Technology for Rail**
  Tier 4 emissions standards for locomotives is 1.3 grams per brake horsepower-hour (g/bhp-hr) for NOx and 0.03 g/bhp-hr for PM. The locomotive manufacturers achieve these numbers with a combination of heavy exhaust gas recirculation (EGR) and particulate filters or selective catalytic reduction (SCR) with diesel exhaust fluid (DEF). However, the use of EGR reduces fuel economy, and very few Tier 4 locomotives have been manufactured since 2015. Utilizing CNG and or

hydrogen as fuel for locomotives will help reduce emissions beyond Tier 4 and provide a cost-effective solution for the rail industry. Relevant regulations and policy drivers include:

  - AB 32 – Reducing CO2 emissions
  - EO B-32-15
  - LCFS
  - SB 1275

- **Area 2: Zero and Near-Zero Emission Technology for Marine**
  Off-road mobile sources account for over 40% of NOx emissions in the South Coast Basin. These sources are from rail, marine, aviation, and other industries. The marine industry is subjected to stringent emissions standards starting in 2020 that all marine vessels need to meet. In addition, hoteling and shore-power for marine applications is a significant source of emissions in the basin. Research and development in this area will help provide emission reductions that are surplus to regulatory requirements. Relevant regulations and policy drivers include:
  - IMO 2020
  - AB 32 – Reducing CO2 emissions
  - In-use compliance requirements of CARB Commercial Harbor Craft regulations
  - EPA marine engine emissions standards
- **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 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. Relevant regulations and policy drivers include:
  - AB 32 – Reducing CO2 emissions
  - LCFS
  - SB 1275

4.4 Refueling Stations

4.4.1 Sub-Program Overview

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

4.4.2 Sub-Program Benefits

Clean Transportation Program: Refueling Stations Sub-Program	
Benefits	**Explanation**
Reliability	Refueling station technologies allows stations to efficiently compress gases, deliver adequate fuel to drivers, minimize losses due to compression, and notifies station operators of any leaks or maintenance issues. This research provides safety benefit and reliability to both station and vehicle operators.
Safety	Refueling station technologies allows stations to efficiently compress gases, deliver adequate fuel to drivers, minimize losses due to compression, and notifies station operators of any leaks or maintenance issues. This research provides safety benefit and reliability to both station and vehicle operators.
Operational Efficiencies	Advanced fueling technologies provide station and vehicle operators with detailed information related to number of incidents and any excess refueling, reducing any unnecessary consumption or leakage, to address environmental benefits and operational efficiencies.
Environmental Benefits	Advanced fueling technologies provide station and vehicle operators with detailed information related to number of incidents and any excess refueling, reducing any unnecessary consumption or leakage, to address environmental benefits and operational efficiencies.

4.4.3 Unique elements

- **On-Road and Off-Road Refueling:** SoCalGas provides meaningful support for the unique needs of on- and off-road refueling programs**.**
- **Experience:** SoCalGas owns and operates a number of CNG fueling stations, and understands the challenges associated with vehicle refueling.

4.4.4 2021 Funding Allocation and Key Research Areas

Clean Transportation Program	
Refueling Stations Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 103,030
Funds for Projects Under Development for 2021	$ 31,522
Total Sub-Program Funding for 2021	$ 134,582
Sub-Program Percentage of Program Funding	7%

Based on input received during outreach activities, in 2021, this sub-program will target the following three 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 vehicles. This help alleviates range anxiety and better adoption of gaseous vehicles that significantly reduce emissions versus its liquid fuel counterparts. Relevant regulations and policy drivers include:
    - AB 8
    - LCFS
    - SB 1275
    - AB 32 – Reducing CO2 emissions
- **Area 2: Hydrogen Refueling Station Optimization**
  HFCVs are heavily researched and demonstrated. Without optimizing refueling stations to serve these vehicles, the technology will struggle to be adopted by transit and goods movement. This research will look at improving hydrogen compressors, increasing the efficiency of overall refueling stations, and alternative technologies for refueling stations. Relevant regulations and policy drivers include:
    - AB 8
    - EO B48-18
    - LCFS
    - SB 1275
    - AB 32 – Reducing CO2 emissions
- **Area 3: Gaseous Refueling Station Safety**
  Hydrogen and CNG as transportation fuel operate at high pressures, 10,000 psi and 3,600 psi respectively. Safety and standardization for station technologies is imperative for the successful adoption of both NGVs and HFCVs. Safety of refueling stations and components is a top priority for the station and vehicle operators of zero- and near-zero-emission vehicles. Relevant regulations and policy drivers include:
    - AB 8
    - EO B48-18
    - LCFS
    - SB 1275
    - AB 32 – Reducing CO2 emissions

4.5 Onboard Storage

4.5.1 Sub-Program Overview

This sub-program targets the development, demonstration, and deployment of 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.

4.5.2 Sub-Program Benefits

Clean Transportation Program: Onboard Storage Sub-Program	
Benefits	**Explanation**
Reliability	Advanced storage tank technologies allow compressed gases to be stored at lower pressures, which increases the safety of storing gases and less wear and tear on the compressors. This research provides a safety benefit and reliability.
Safety	Advanced storage tank technologies allow compressed gases to be stored at lower pressures, which increases the safety of storing gases and less wear and tear on the compressors. This research provides a safety benefit and reliability.
Operational Efficiencies	Advanced storage tank technologies allow compressors to operate at lower pressure, which increase environmental benefits and operational efficiencies by consuming less electricity, compressing less gas, and less wear and tear on compressors. This research provides environmental benefits and operational efficiencies.
Environmental Benefits	Advanced storage tank technologies allow compressors to operate at lower pressure, which increase environmental benefits and operational efficiencies by consuming less electricity, compressing less gas, and less wear and tear on compressors. This research provides environmental benefits and operational efficiencies.

4.5.3 2021 Funding Allocation and Key Research Areas

Clean Transportation Program	
Onboard Storage Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 15,000
Funds for Projects Under Development for 2021	$ 157,794
Total Sub-Program Funding for 2021	$ 172,794
Sub-Program Percentage of Program Funding	8%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Conformable Tanks**
  Today's NGVs are fitted with on-board fuel tanks that are too large, cumbersome, and expensive to properly facilitate the widespread adoption of NGVs in the U.S. and globally. Additionally, the low volumetric density of natural gas--roughly 30% less energy by volume than gasoline--limits the driving range of NGVs and makes cost-effective storage solutions a significant challenge. Dramatic improvements must be made to the capacity, conformability, and cost of on-board storage to accelerate NGV adoption. Conformable tanks store high-pressure compressed natural gas in the same place on a vehicle where gasoline is stored today, yet still has enough gas to meet the desired driving range of the vehicle. Relevant regulations and policy drivers include:
    - AB 8
    - EO B48-18
    - LCFS
    - SB 1275
    - AB 32 – Reducing CO2 emissions
    - EO B-32-15

- **Area 2: Low-Pressure Tanks**
  Gaseous vehicles operate at extremely high pressure. For NGVs, the operating pressure is 3600 psi and 10,000 psi for HFCVs. Low pressure tank technology allows NGVs and HFCVs to operate at one-quarter of the pressure or lower with the same amount of range. This not only helps reduce the size of the pressure vessel on board, but also helps reduce emissions from infrastructure. Lower pressure tanks also improve compressors and station component reliability. Relevant regulations and policy drivers include:
    - AB 8
    - EO B48-18
    - LCFS
    - SB 1275
    - AB 32 – Reducing CO2 emissions
    - EO B-32-15
- **Area 3: Advanced Storage Tank Materials**
  A significant challenge for NGVs and HFCVs is the onboard storage tank. Currently, CNG tanks have a lifespan of 12 to 15 years with hydrogen tanks roughly around the same. These tanks also add significant cost and weight to vehicles. Researching in advanced materials for onboard storage tanks will help reduce overall cost, weight, and increase the safety and reliability of the tanks. Over the next decade, a significant market is expected to develop for fuel cell powered products. These products will be designed to provide clean, quiet, vibration-free electric power on demand for a variety of applications in the transportation and industrial vehicle, stationary power and portable power markets. Relevant regulations and policy drivers include:
    - AB 8
    - EO B48-18
    - LCFS
    - SB 1275
    - AB 32 – Reducing CO2 emissions
    - EO B-32-15

4.6 Visual Summary of Proposed 2021 Funding Allocation

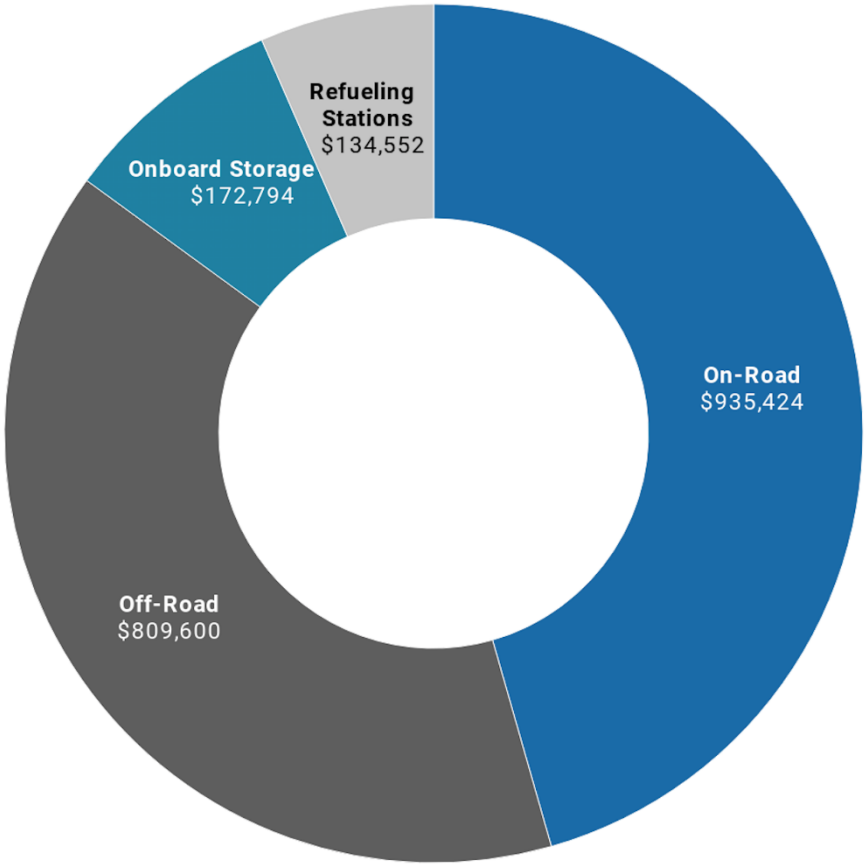


Figure 5: Clean Transportation 2021 sub-program budget breakdown.

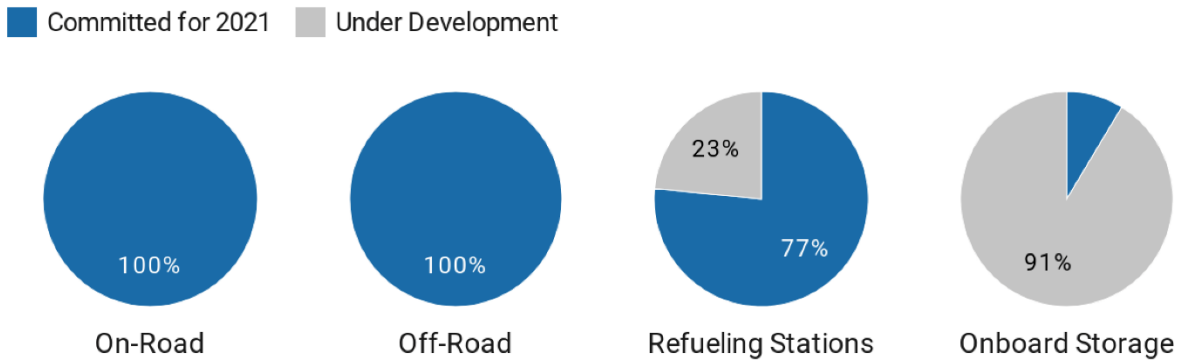


Figure 6: Clean Transportation sub-program split between committed 2021 funds and funds under development.

5.0 Clean Generation

5.1 Overview, Goals, and Structure

This program 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, and improve energy reliability and resiliency. Clean Generation is composed of two sub-programs: 1) Integration & Controls and 2) Distributed Generation (DG).

5.2 Integration & Controls

5.2.1 Sub-Program Overview

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

5.2.2 Sub-Program Benefits

Clean Generation Program: Integration & Controls Sub-Program	
Benefits	**Explanation**
Reliability	Simplifying the integration of high performing gas DG to meet specific customer needs can improve power reliability and resilience.
Safety	Simplifying and standardizing the integration of fuel cells and other gas DG with solar and battery storage can improve the safety of installing and operating such systems, which are usually highly complex and customized. Also, by integrating fuel cells or other gas DG in microgrids, community safety can be enhanced by maintaining power to critical infrastructure.
Operational Efficiencies	Integrating gas DG in microgrids can boost overall customer efficiency, both electrical and thermal (if CHP is implemented).
Environmental Benefits	Integrating and optimizing gas DG in microgrids can reduce overall customer emissions when accounting for grid-source emissions. Gas DG can also displace diesel backup generators when a microgrid is islanded or needs peak generation.

5.2.3 2021 Funding Allocation and Key Research Areas

Clean Generation Program	
Integration & Controls Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 553,500
Funds for Projects Under Development for 2021	$ 252,800
Total Sub-Program Funding for 2021	$ 806,300
Sub-Program Percentage of Program Funding	50%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Integration of Solid Oxide Fuel Cells (SOFC) with Solar and Battery Storage**
  Projects in this area seek to demonstrate small SOFCs integrated with solar and battery storage in residential and small commercial installations and how SOFCs can provide increased resilience—as well as potential emission reductions and cost savings—for small-scale microgrids. This area addresses the stakeholder comment regarding how RNG and hydrogen can interface with other renewables and energy storage (Appendix A.1.d). Relevant regulations and policy drivers include:
  - SB 1339
  - AB 3232 – Building Decarbonization
  - SB 100
  - Clean Air Act
- **Area 2: Integration of Fuel Cells with Existing 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 and heating systems at customer sites. Microgrids are highly customized, which can result in high implementation costs. Identifying off-the-shelf components to simplify installations for customers will ideally reduce cost and other complications. System complication and lack of clear hardware requirements are significant barriers to adoption. This area addresses the stakeholder comments regarding prioritizing projects that inform future building codes (Appendix A.3.a), advancing microgrids (Appendix A.3.o), and standardization across application (Appendix A.6.n). Relevant regulations and policy drivers include:
  - SB 1339
  - AB 3232 – Building Decarbonization
  - SB 100
  - Clean Air Act
- **Area 3: Integration of Gas-Fueled Backup Generation with Existing Customer Systems**
  Projects in this area seek to demonstrate how gas-fueled backup generation can be seamlessly integrated with existing customer systems to provide increased resilience. Unlike the SOFCs in

Area 1, 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. They also want clarity on how low-emissions natural gas- or hydrogen-fueled generation technologies can address this need. This area addresses the stakeholder comments regarding decarbonization alternatives (Appendix A.1.b, A.1.c) and prioritizing grid integration of hydrogen and storage (Appendix A.3.l). Relevant regulations and policy drivers include:

- SB 1339
- AB 3232 – Building Decarbonization
- SB 100
- Clean Air Act

5.3 Distributed Generation

5.3.1 Sub-Program Overview

This sub-program develops and enhances distributed generation technologies. Microgrids and the increasing availability of RNG and hydrogen offer new opportunities for the deployment of low-emission and renewably-fueled DG technologies.

5.3.2 Sub-Program Benefits

Clean Generation Program: Distributed Generation Sub-Program	
Benefits	**Explanation**
Reliability	Developing high-performing gas generation technologies can improve power reliability and resilience for customers on a daily basis. Also, developing alternatives that are more reliable than unused backup diesel generators can improve power reliability.
Safety	Several projects in this sub-program are targeted towards testing and modifying existing power generation technologies to safely operate on hydrogen. Improving the operational efficiency and emissions of DG technology reduces customers' exposure to poor air quality. Efficient and reliable DG also improves community safety by maintaining power to critical infrastructure, such as hospitals.
Operational Efficiencies	Developing high-performing CHP technologies can provide energy reliability and resilience, while also providing process heat, which boosts overall efficiency.
Environmental Benefits	Improving the efficiency and emissions performance of gas engines and turbines reduces emissions. Developing technologies that can replace high-polluting diesel backup generators also reduces emissions. Development of fuel cells reduces NOx and CO2 emissions when compared to the grid-sourced power.

5.3.3 2021 Funding Allocation and Key Research Areas

Clean Generation Program	
Distributed Generation Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 639,537
Funds for Projects Under Development for 2021	$ 166,763
Total Sub-Program Funding for 2021	$ 806,300
Sub-Program Percentage of Program Funding	50%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Commercialization of Solid Oxide Fuel Cell**
  Projects in this area seek to help commercialize a SOFC for residential and/or small commercial customers. Small-scale SOFC units are widely available in Japan, Europe, and recently Korea. There are currently no commercially available small SOFCs in the U.S. Lab testing and system optimization needs to occur, along with obtaining safety certifications. This area addresses the stakeholder comments regarding prioritizing fuel cell development (Appendix A.3.n). Relevant regulations and policy drivers include:
    - AB 3232 – Building Decarbonization
    - SB 100
    - Clean Air Act
- **Area 2: Carbon Capture from Solid Oxide Fuel Cell Technology**
  SOFC technology virtually eliminates NOx emissions, but still emits CO2. In order to decarbonize gas fueled DG, ways to capture CO2 will need to be developed and implemented. Such technology would enable increased resilience, while addressing AB 3232 requirements for building decarbonization. This area addresses the stakeholder comments regarding decarbonization alternatives (Appendix A.1.b) and utilization of existing infrastructure to support decarbonization (Appendix A.1.c). Relevant regulations and policy drivers include:
    - AB 3232 – Building Decarbonization
    - SB 100
    - Clean Air Act
- **Area 3: Hydrogen Integration with Existing Distributed Generation Technologies**
  Continue to test and identify pathways for increased levels of hydrogen blending for engine and turbine-based DG currently operating on natural gas. Identifying and increasing hydrogen thresholds of existing DG equipment is a critical component of SoCalGas' hydrogen roadmap. This area addresses the stakeholder comments regarding prioritizing research for hydrogen blending (Appendix A.3.b) and grid integration of hydrogen (Appendix A.3.l). Relevant regulations and policy drivers include:
    - AB 3232 – Building Decarbonization
    - SB 100
    - Clean Air Act

5.4 Visual Summary of Proposed 2021 Funding Allocation

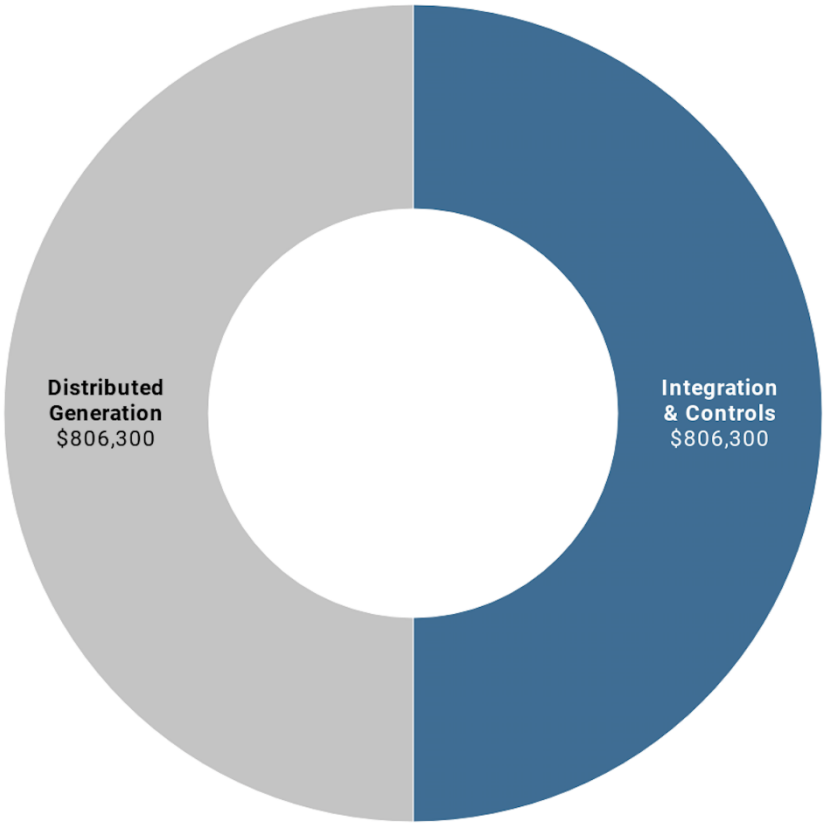


Figure 7: Clean Generation 2021 sub-program budget breakdown.

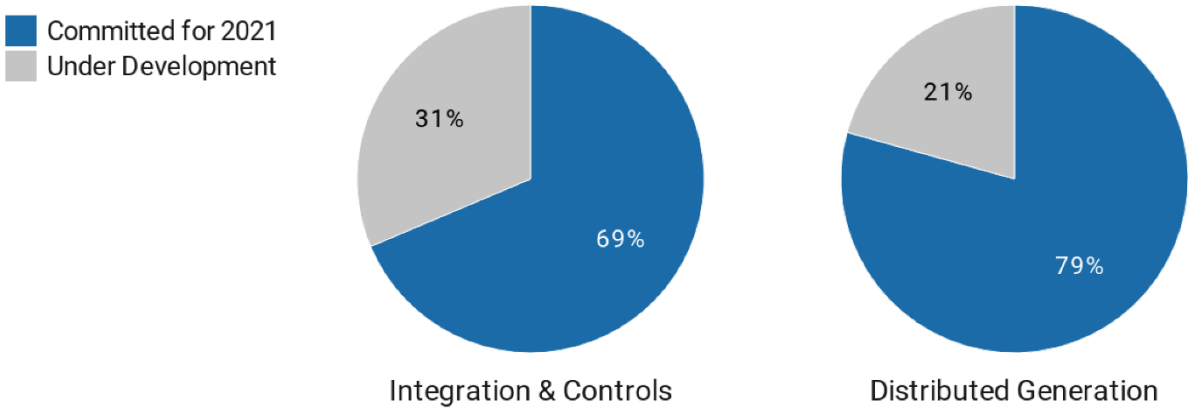


Figure 8: Clean Generation sub-program split between committed 2021 funds and funds under development.

6.0 Customer End-Use Applications

6.1 Overview, Goals, and Structure

This program 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.

Customer End-Use Applications is composed of five sub-programs: 1) Commercial Food Service, 2) Residential Appliances, 3) Commercial Applications, 4) Industrial Process Heat, and 5) Advanced Innovation.

6.2 Commercial Food Service

6.2.1 Sub-Program Overview

This sub-program develops and enhances technologies and advancements related to commercial food service (CFS). This includes restaurants, catering services, and institutional kitchens that primarily rely on fuel supplied by SoCalGas for cooking and water heating.

6.2.2 Sub-Program Benefits

Customer End-Use Applications Program: Commercial Food Service Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Projects in this sub-program seek to increase energy efficiency and burner performance, which provides an environmental benefit by reducing emissions from CFS equipment.
Operational Efficiencies	Increasing energy efficiency and burner performance also provides improved operational efficiency for customers by reducing cooking time and reducing fuel cost.

6.2.3 2021 Funding Allocation and Key Research Areas

Customer End-Use Applications Program	
Commercial Food Service Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 57,600
Funds for Projects Under Development for 2021	$ 100,000
Total Sub-Program Funding for 2021	$ 157,600
Sub-Program Percentage of Program Funding	8%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Commercial Food Service Equipment Emissions Survey**
  SCAQMD's 2016 Plan calls for NOx reductions from Emission Reductions from Restaurant Burners and Residential Cooking (CMB-04). To properly guide technology development to reduce NOx in CFS, a survey of equipment is required to establish the correct emissions baseline for customers. Relevant regulations and policy drivers include:
    - 2016 Air Quality Management Plan (AQMP) CMB-04
    - Clean Air Act
- **Area 2: Commercial Food Service Equipment Emissions Reduction Roadmap**
  Results from an equipment survey can be used with SMEs in emissions reduction to identify the best opportunities for emissions reduction in CFS. Projects in this area seek to compare most common equipment, highest-emitting equipment, highest feasibility for emissions reduction, etc. Relevant regulations and policy drivers include:
    - 2016 AQMP CMB-04
    - Clean Air Act
    - AB 617 – Pilot communities for air quality improvement
- **Area 3: Hydrogen Blends in Commercial Food Service Equipment**
  Projects in this area seek to investigate how hydrogen blends impact the performance of CFS, especially around cooking efficiency and NOx emissions. Relevant regulations and policy drivers include:
    - AB 32 – Reducing CO2 emissions
    - AB 3232 – Building Decarbonization

6.3 Residential Appliances

6.3.1 Sub-Program Overview

This sub-program develops and enhances technologies and advancements related to gas-consuming appliances in residences. Relevant appliances include furnaces, hot water heaters, stoves, ovens, and dryers.

6.3.2 Sub-Program Benefits

Customer End-Use Applications Program: Residential Appliances Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Increasing energy efficiency and burner performance for residential appliances provides an environmental benefit by reducing NOx, PM, and GHG emissions. Developing advanced appliances that are compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from residential buildings.

Customer End-Use Applications Program: Residential Appliances Sub-Program	
Benefits	**Explanation**
Operational Efficiencies	Increasing energy efficiency and burner performance for residential appliances also provides improved operational efficiency for customers by reducing fuel cost associated with space conditions, water heating, and cooking.
Safety	Improving burner performance and reducing NOx and PM emissions from residential appliances increases the safety of the user by improving local and IAQ.

6.3.3 2021 Funding Allocation and Key Research Areas

Customer End-Use Applications Program	
Residential Appliances Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 785,600
Funds for Projects Under Development for 2021	$ 115,000
Total Sub-Program Funding for 2021	$ 900,600
Sub-Program Percentage of Program Funding	44%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Hydrogen Boiler Testing**
  A European manufacturer has produced a prototype residential boiler that runs on pure hydrogen. Area 1 research would aim to procure a unit for lab testing in the U.S. to understand the feasibility of use in the SoCalGas service territory. Relevant regulations and policy drivers include:
  - AB 32 – Reducing CO2 emissions
  - AB 3232 – Building Decarbonization
- **Area 2: Residential Gas Heat Pump Imports**
  Several European manufacturers have commercialized residential gas heat pump water heaters. Area 2 research would coordinate efforts by U.S. manufacturers and distributors to modify those products for deployment in the U.S., particularly in the SoCalGas service territory. Relevant regulations and policy drivers include:
  - AB 32 – Reducing CO2 emissions
  - AB 3232 – Building Decarbonization
- **Area 3: Hydrogen Home Demonstration Concept**
  Building on work done in Canada, projects in this area will design and build a concept home powered exclusively by hydrogen, with the goals of demonstrating the feasibility of an all

hydrogen home and identifying associated technical, permitting, and safety challenges. Relevant regulations and policy drivers include:

- AB 32 – Reducing CO2 emissions
- AB 3232 – Building Decarbonization

6.4 Commercial Applications

6.4.1 Sub-Program Overview

This sub-program 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.

6.4.2 Sub-Program Benefits

Customer End-Use Applications Program: Commercial Applications Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Increasing energy efficiency and burner performance for commercial equipment provides an environmental benefit by reducing NOx, PM, and 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.
Operational Efficiencies	Increasing energy efficiency and burner performance for commercial equipment also provides improves operational efficiency for customer by reducing fuel cost associated with space conditions, water heating, and other commercial operations.
Safety	Improving burner performance and reducing NOx and PM emissions from commercial equipment increases safety for commercial customers, their tenants, and their clients by improving indoor and local air quality.

6.4.3 2021 Funding Allocation and Key Research Areas

Customer End-Use Applications Program	
Commercial Applications Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 75,715
Funds for Projects Under Development for 2021	$ 160,000
Total Sub-Program Funding for 2021	$ 235,715
Sub-Program Percentage of Program Funding	11%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: High Efficiency Commercial Clothes Dryer Development**
  Building on previous prototype work, projects in this area seek to advance the development of an extremely high-efficiency commercial clothes dryer and to identify potential commercialization partners. Relevant regulations and policy drivers include:
  - AB 32 – Reducing CO2 emissions
  - AB 3232 – Building Decarbonization
- **Area 2: Commercial Gas Heat Pump Demonstration**
  There are a number of gas heat pump products available for commercial buildings that could significantly reduce GHG emissions. Projects in this area will field-demonstrate these products to identify and address hurdles to widespread deployment. Relevant regulations and policy drivers include:
  - AB 32 – Reducing CO2 emissions
  - AB 3232 – Building Decarbonization
- **Area 3: Hydrogen Blends in Commercial Equipment**
  Projects in this area seek to investigate how hydrogen blends impact the performance of commercial equipment, with particular focus on NOx emissions. Projects will identify feasible modifications to equipment to accommodate higher blends. Relevant regulations and policy drivers include:
  - AB 32 – Reducing CO2 emissions
  - AB 3232 – Building Decarbonization

6.5 Industrial Process Heat

6.5.1 Sub-Program Overview

This sub-program develops advanced heating technologies and systems for use in the industrial sector. Relevant applications include food processing, textile drying, chemical processing, and other process heat needs.

6.5.2 Sub-Program Benefits

Customer End-Use Applications Program: Industrial Process Heat Sub-Program	
Benefits	**Explanation**
Environmental Benefits	Increasing energy efficiency and burner performance for industrial equipment provides an environmental benefit by reducing NOx, PM, and GHG emissions. Developing advanced industrial equipment that is compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from industrial process, which are difficult and costly to electrify.

Customer End-Use Applications Program: Industrial Process Heat Sub-Program	
Benefits	**Explanation**
Operational Efficiencies	Increasing energy efficiency and burner performance for industrial equipment also provides improves operational efficiency for industrial customers by reducing fuel costs associated with high-temperature processes.
Safety	Improving burner performance and reducing NOx and PM emissions from industrial equipment increases safety for customers by improving indoor and local air quality.

6.5.3 2021 Funding Allocation and Key Research Areas

Customer End-Use Applications Program	
Industrial Process Heat Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 270,570
Funds for Projects Under Development for 2021	$ 350,000
Total Sub-Program Funding for 2021	$ 620,570
Sub-Program Percentage of Program Funding	30%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Heavy Industrial Process Improvements**
  RD&D personnel identified heavy industrial customers interested in adopting new technologies to reduce GHG emissions from production processes. Most have already installed best available commercial equipment. Thus, additional reductions will require new, advanced technology. Area 1 research will attempt to identify technology options and conduct feasibility demonstrations. Relevant regulations and policy drivers include:
    - EO B-55-18: Carbon-neutral California economy by 2045
    - AB 32 – Reducing CO2 emissions
- **Area 2: Industrial Drying Technology Commercialization**
  Building on a successful demonstration in partnership with the CEC, projects in this area will develop a commercialization plan for the thermo-vacuum dryer technology in agricultural applications. Relevant regulations and policy drivers include:
    - EO B-55-18: Carbon-neutral California economy by 2045
    - AB 32 – Reducing CO2 emissions
- **Area 3: Hydrogen Blends in Commercial Equipment**
  Industrial processes, with high energy loads and high temperature requirements, are extremely

difficult to electrify. Projects in this area will investigate how hydrogen blends impact the performance of industrial equipment, with particular focus on NOx emissions. Area 3 projects will also seek to identify feasible modifications to equipment to accommodate higher blends. Relevant regulations and policy drivers include:

- EO B-55-18: Carbon-neutral California economy by 2045
- AB 32 – Reducing CO2 emissions

6.6 Advanced Innovation

6.6.1 Sub-Program Overview

This new sub-program seeks to develop new technologies to increase energy efficiency and decrease emissions.

6.6.2 Sub-Program Benefits

Customer End-Use Applications Program: Advanced Innovation Sub-Program	
Benefits	**Explanation**
Environmental Benefits	This sub-program strives to reduce customers' overall energy usage through building envelope improvements, advanced insulating materials, and smart/IoT monitoring technologies. By reducing energy usage, these innovations provide environmental benefit by reducing associated NOx, PM, and GHG emissions.
Operational Efficiencies	These innovations provide operational efficiencies by reducing customers' overall energy and fuel costs and reducing maintenance expenses (either through reduced duty cycle or predictive failure detection).
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 and IAQ.

6.6.3 2021 Funding Allocation and Key Research Areas

Customer End-Use Applications Program	
Advanced Innovation Sub-Program 2021 Funding Allocation	
Committed Funds for 2021	$ 62,915
Funds for Projects Under Development for 2021	$ 75,000
Total Sub-Program Funding for 2021	$ 137,915
Sub-Program Percentage of Program Funding	7%

Based on input received during outreach activities, in 2021, this sub-program will target the following three key research areas with funds for projects under development:

- **Area 1: Smart Gas Appliances**
  Projects in this area seek to investigate the use of smart technology to reduce fuel use in gas appliances. Relevant technologies could include smart sensors to reduce operation during low demand times (e.g. vacation settings), Wi-Fi connectivity for demand side management, and more. Relevant regulations and policy drivers include:
    - AB 3232 – Building Decarbonization
    - AB 32 – Reducing CO2 emissions
- **Area 2: Advanced Materials for Building Energy Efficiency**
  Building envelope energy efficiency measures can reduce fuel use and emissions without replacing any equipment. Area 2 projects seek to investigate advanced materials (e.g., phase change polymers) that can improve energy efficiency in building. Relevant regulations and policy drivers include:
    - AB 3232 – Building Decarbonization
    - AB 32 – Reducing CO2 emissions
    - U.S. Green Buildings Council's Leadership for Energy and Environmental Design (USGBC LEED)
- **Area 3: Smart Ventilation**
  CARB has identified improved ventilation (to remove any existing pollutants from the home) as a key strategy for improving IAQ. A 2020 UCLA School of Public Health study found that less than 35% of Californians use range hoods to ventilate cooking by-products that impact IAQ. Area 3 research will investigate methods to improve ventilation use through education, awareness, indoor sensors, and automated range hoods. Relevant regulations and policy drivers include:
    - Clean Air Act
    - EPA Indoor airPLUS program
    - USGBC LEED

6.7 Visual Summary of Proposed 2021 Funding Allocation

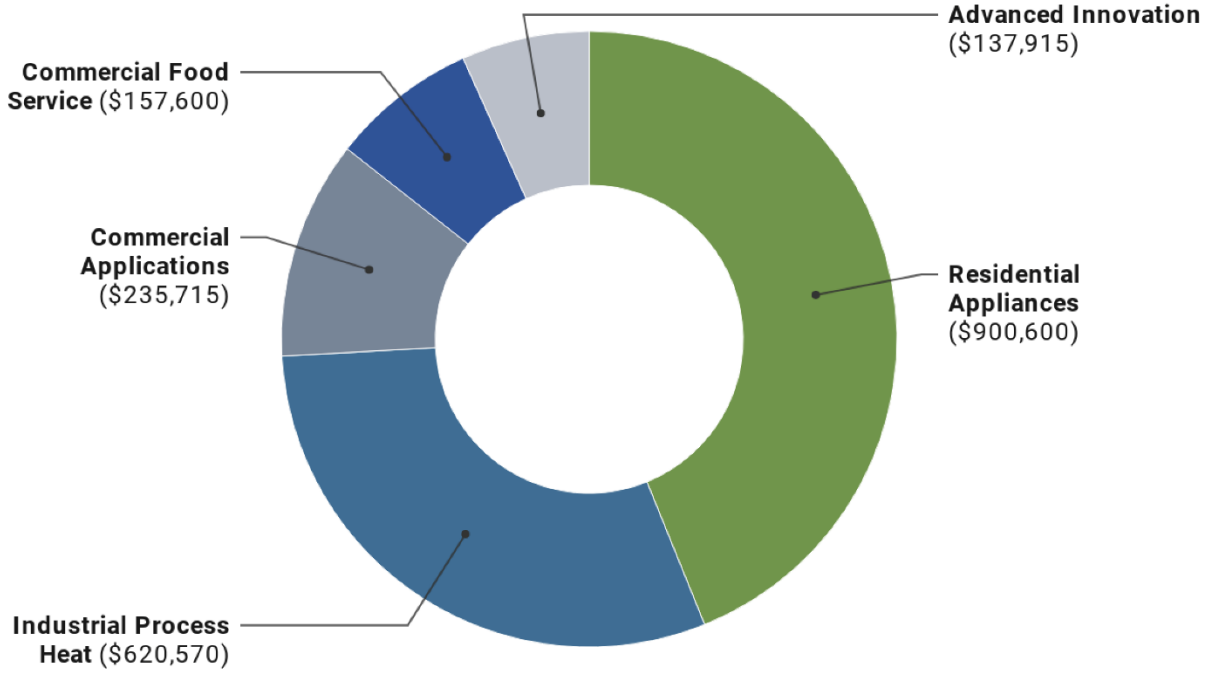


Figure 9: Customer End-use Applications 2021 sub-program budget breakdown.

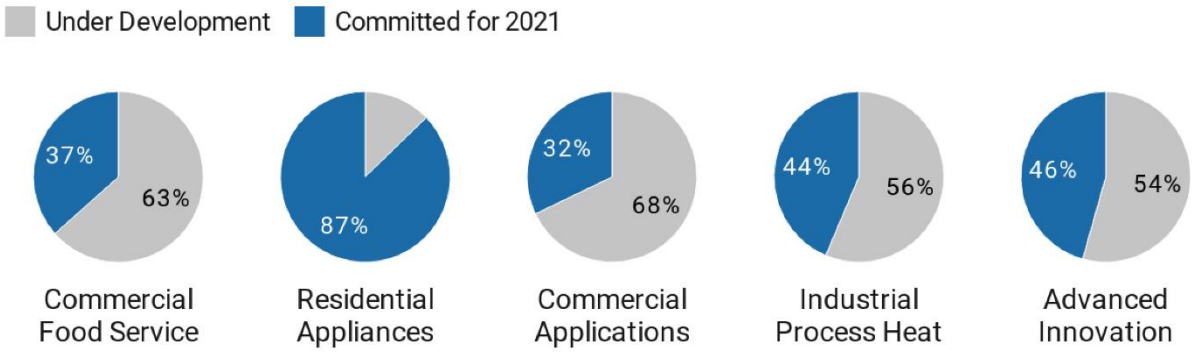


Figure 10: Customer End-use Applications sub-program split between committed 2021 funds and funds under development.

Appendix A: Stakeholder Input

Prior to the workshop, several stakeholders were interviewed individually to collect input to drive the development of the 2021 Research Plan. This table lists the questions posed during the interviews and a summary of responses from the various stakeholders.

Question	Responses
1. What technical questions are most pressing from a research standpoint?	a. What role should hydrogen play? Is it a realistic alternative to fossil fuels? b. What decarbonization alternatives exist in the industrial space? c. How can we use the existing infrastructure to support decarbonization? d. How do RNG and hydrogen interface with other renewables, energy storage, and ancillary services? e. How can we make existing homes as efficient as new homes? f. How can gas companies reduce carbon intensity and transition to RNG and hydrogen? g. What are the implications to gas customers of displacing natural gas with hydrogen? h. How can inspection technologies help better predict and prevent pipeline failure? i. How can we improve decision-making about infrastructure to reduce methane emissions?

Question	Responses
2. What pain points must be addressed for natural gas customers?	a. Need more programs benefiting low-income and disadvantaged community customers with poor air quality. b. Aging infrastructure and safety. c. How can we develop larger demonstration projects for decarbonization technologies? d. Reducing methane emissions and leakage. e. How can we scale up hydrogen production to meet the demands of industry and transportation? f. Lack of trained technicians. g. High soft and installation costs. h. RD&D Program budget is too small to be effective. Need to increase funding. i. High costs of alternative energy.
3. What are your top three research priorities?	a. Research necessary to inform future building code changes, with emphasis on advocating for higher-efficiency equipment. b. Blending hydrogen in the gas pipeline. c. Using data to perform predictive analysis. d. How new forms of energy impact existing infrastructure. e. Autonomous pipeline inspection robots. f. Methane emissions and leak detection. g. Decarbonization via conversion of woody biomass to RNG. h. RNG production for transportation or stationary fuel cells for EV charging. i. Heavy-duty trucks and refueling infrastructure. j. Responsive, “hour ahead” energy storage. k. Low-cost hydrogen production. l. Grid integration of hydrogen and storage. m. Hydrogen transportation applications. n. Stationary fuel cells fueled by natural gas, RNG, and biogas. o. Microgrids.

Question	Responses
4. What is your overall assessment of the SoCalGas RD&D Program?	a. SoCalGas focuses on the needs of its ratepayer; there is a need for that. b. RD&D Program can bring together natural gas customers and technology providers to demonstrate new technologies. c. SoCalGas is on the cutting edge of the transition away from fossil gas. d. SoCalGas stands apart from virtually all utilities in the U.S. and Canada with respect to RD&D and is doing an excellent job finding co-funders for projects. e. RD&D Program is nicely flexible in comparison to other programs. f. SoCalGas is in the trenches and can address key questions faster than many funding agencies.
5. What are the key policy drivers that SoCalGas RD&D should consider?	a. Decarbonization, resilience, affordability, and equity. b. Building efficiency code standards, such as Title 24 and 20. c. AB3232: Building decarbonization. d. Need for changing perception of alternative-fueled rail and off-road equipment. e. Low Carbon Fuel Standard and Renewable Fuels Standard. f. Tax credits for carbon capture and sequestration. g. Changes to heavy-duty truck regulations. h. SB1371: Natural gas leak abatement. i. Resistance to natural gas incentive programs at state level. j. Consequences of transportation electrification on gas grid.

Question	Responses
6. What are some gaps in the RD&D landscape?	a. It is hard to find technologies that apply across multiple facilities and applications. b. Identifying and eliminating fugitive emissions from gas pipelines. c. Inspection programs for plastic pipelines. d. Data about impact of blending RNG and hydrogen into the gas pipeline. e. Predictive maintenance tools and processes. f. There is a need for larger demonstration projects, particularly around decarbonization, and better data. g. Need more activity around standards for heavy-duty trucks. h. Need for more knowledge about the connection between stationary hydrogen and transportation infrastructure. i. Better education and training about hydrogen safety. j. Exploration of hydrogen use at railyards and ports. k. Use of hydrogen in large vehicles and equipment. l. A clear roadmap for transition from natural gas to RNG and hydrogen and viable pathways to that goal. m. Large-scale demonstration of hydrogen storage. n. Standardization across applications.

Question	Responses
7. What should SoCalGas consider to strengthen its RD&D Program?	a. Further develop what the program is already doing: analyzing needs, collecting data, exploring the use of AI. b. Increase the program's budget. c. Identify more potential co-funders to share expenses. d. Improve outreach to the Air Districts and general public about what the program is and does. e. Organize responses to misperceptions about natural gas to improve the company's image. f. Demonstrate how gas companies are collaborating to fix leaks and waste. g. Inform and educate policy makers about the importance of the continued existence gas companies in the future and the role they will play in a renewable gas grid. h. Invest heavily in a powerful vision document that is fully supported from the top down. i. Look for the opportunities that exist within current challenges and build business models around them.
8. Whom else should we talk to?	a. California Air Resources Board about carbon capture projects. b. American Gas Association c. Enbridge, Inc. R&D Program staff. d. Southern Company e. Office of Consumer Council in order to see what potential opposition thinks. f. Dan Kammen at University of California, Berkeley about economic analysis. g. Marc Fischer, Berkeley Lab about methane leakage, safety. h. Product end-users. i. European researchers facing similar challenges.

Appendix B: Workshop Questions, Comments, and Answers

Questions and comments given during the public workshop held on April 24, 2020, are shown below in **bold** text; answers provided by SoCalGas are shown in *italics*.

1. Overview

a. **How long do these projects typically last?**

   i. *Each project length varies. Some can last a few months, and some can last multiple years. Please see the Annual Report for specific project information which includes their lengths.*

b. **What % of SC Gas is the $18 M contributed to R&D.**

   i. *Thank you for the question. The RD&D budget is roughly 0.5% of the total annual revenue requirement for SoCalGas.*

c. **What are SoCal Gas membership dues to OTD and UTD?**

   i. *Consortium dues: The dues are based upon the number of customer meters for each utility. For SoCalGas it is the maximum: OTD $750,000 and UTD $350,000. While these are referred to as "dues," the funding is used to support research projects conducted by the consortium.*

d. **What investments are you making in the CSU schools? This is where the young people from underserved communities go to college, getting engineering and business degrees, and graduating to come to work for you. Investments in these schools will be an investment in low income communities, and build future employees and provide education about RNG, H2, etc. to these young people. Why invest heavily only in the UCs? Disclaimer: I'm from CSULA**

   i. *Thank you for this question and comment. There's at least one project with CSULA that you can find in the Annual Report. Very good points on why to work more with them.*

e. **Where can I find the call for SoCalGas environmental grant program (the one that is maxed at $25k) for 2020?**

   i. *More information about the Environmental Champions Initiative can be found here: https://www.socalgas.com/our-community/protecting-preserving-the-environment*

f. **Did you reach out to the DAC Advisory Group?**

   i. *Thank you for the question. We did not reach out to the DACAG. We did work with our Regional Public Affairs team to identify and invite over 100 DAC and low-income community stakeholders.*

g. **I live in an EJ Community, Jurupa Valley. I will be submitting my comments through email.**

   i. *Thank you very much for doing this!*

h. **How has new project development impacted the economic development of communities that your company provides services to?**

    i. *RD&D projects are generally temporary by nature. We strive, however, to provide research that encourages project development and technology deployment that will benefit our customers (through reduced emissions, improved reliability, or lower cost) and their communities (through economic development and job creation).*

i. **How about cost and customer acceptance?**

    i. *Thank you for bringing these up. Certainly a focus, but we'll make sure to note their importance.*

j. **How should a relatively large So Cal Water District be involved in a R&D demo?**

    i. *Thanks for the question on how to get involved. We'll have the team follow-up with different ways to do this. Please connect with the RD&D team via email at RDDInfo@socalgas.com so we can determine the best way to work together.*

k. **Use the CSUs to do workforce training!**

    i. *Thanks for your response.*

l. **We just wanted to make general comments. They have partnered up with SCG on several on our projects that were highlighted this morning such as Hyperlight, Cummins Westport, and with GTI and many others such as – both residential and commercial applications as well as industrial processing and on the transportation side with the gas engines. And so CEC also funds projects that don't appear to be part of the SCG portfolio and providing compliment to utility efforts including studies such as fugitive emissions, climate science and impact on natural gas infrastructure. To address the question this morning on addressing equity and environmental justice, the CEC wants to underscore the importance of this goal. Equity in the drive to even cleaner energy delivery in a low carbon economy, we are focused on this goal as well. And the CEC would offer two resources for your consideration. The first is the CEC's empower platform and so this is a new database that we started last November and is a way how the end-user as well as researchers and financiers and others can link up together. It's a resource to the state's clean energy research programs – researchers, community organizations and funding opportunity's both in the form of grants or venture investors. So any attendees to this workshop are invited to visit that platform and add your profile and share organization needs or funding available for projects. And so it's a great resource for – if you have a sight that wants to be demonstrated and someone has the technology its and opportunity to link up. And recently the CEC revised its grants selection criteria to address benefits to underserved community. And this criterion was developed with input from EJ organizations.**

    i. *Thank you for your comment.*

m. **Thanks very much for the informative workshop**

    i. Thank you for joining!

2. Low Carbon Resources

a. If the RNG uses surplus electric in its utilization, doesn't that increase the requirement for natural gas storage to sync the electric power surplus with the natural gas demand?

i. *RNG production from otherwise curtailed or low-cost renewable electricity provides a decoupling effect between the electricity and NG networks. In other words, RNG production is storing energy when electricity availability is in over-supply and then the stored RNG can be utilized whenever needed. The NG network provides long-term storage solution (e.g., months) for the growing amount of renewable electricity sources. Then the RNG is used in a wide array of sectors including chemical production, transportation fuels, heating and re-electrification to the utility grid.*

b. What is the advantage of converting H2 to CH4 (Conversion of H2 and CO2 to CH4)? when we know H2 has much higher calorific value compared to CH4 and is much more clean?

i. *Methane is more readily transported and stored than hydrogen. Converting to methane allows the gas to be transported using the current pipeline system.*

c. Is total project cost the cost to SoCal Gas only? e.g., $2.4 m for last partnership with US DOE.

i. *$2.4M represents the total funding for JCAP from DOE and other industry partners. SoCalGas provided $100,000 in 2019. Details are available in the 2019 Annual Report.*

d. Has there been any study or data to show whether Methane Pyrolysis (converting CH4 to H2 and carbon nanotube) is more economic or Methanation (converting H2 and CO2 to CH4)? which research path should be prioritized and based on what rational?

i. *PNNL conducted a project to produce a technoeconomic analysis of methane pyrolysis that can be found here: https://www.osti.gov/biblio/1411934-overview-natural-gas-conversion-technologies-co-production-hydrogen-value-added-solid-carbon-products*

e. Hello, the DOE Fuel Cells Technologies Office (FCTO) is interested in hydrogen blending and we have some questions for discussion (more related to the last presentation). How does SoCalGas see hydrogen blending fitting in their roadmap relative to RNG? If considering blending, what %H2 has been tested and have you experienced any issues with e.g. flashback or flame speed, and are some appliances more feasible for the near-term than others? Has there been any work done on materials compatibility, and if so, what parameters are being studied? What materials are being considered for modernization efforts?

i. *Thank you for the question. We'll follow-up with more details. These are important questions about hydrogen blended fuels and highlight the cross-cutting nature of the issue. We would like to connect directly to discuss further. Additionally, the issue of hydrogen injection standards is being addressed in the CPUC rulemaking R.13-02-008 Phase 4. SoCalGas along with the other gas IOUs in California are currently evaluating research to propose a preliminary injection standard. Parties and stakeholders are welcome in this process.*

f. What is the smallest scale of carbon capture that you have considered (e.g. kiosks inside of a building) @electrostasis

i. *We have considered small scale CO2 capture devices using microchannel technology, including a NASA CO2 capture device based on microchannel technology (heat exchanger microchannels integrated with temperature swing sorbent microchannels). We are also monitoring feasibility work by Fortis BC on technology from CleanO2 that captures carbon emissions from small commercial boilers.*

g. Has your prior funding and interaction with JCAP enabled any advances in carbon capture within this space? @electrostasis

i. *We'll check to get clarification on that. In addition to basic and applied research in electrocatalysis and photoelectrocatalysis, JCAP focuses on process integration and system prototyping. As a result of progress in each of these R&D "thrusts," SoCalGas RD&D is planning to do a pilot demonstration project with JCAP in 2021 and 2022.*

3. Clean Transportation

a. Will future funding be allocated to hydrogen infrastructure? If so, can you say how much?

i. *Thank you for this question. Hydrogen infrastructure is an integral research area for transportation. Infrastructure related projects fall into "Refueling Station" sub-program. For 2021, we have allocated a portion of the Clean Transportation Budget for infrastructure related topics and welcome further discussions on Hydrogen Infrastructure.*

b. What type of hydrogen storage systems are you considering? Is there interest in technologies utilizing molecules, such as ammonia. Our team is working on anhydrous ammonia and would welcome opportunity to share our tech brief with your team for feedback.

i. *Thank you for your question and input. At this point, SoCalGas is focused on using the natural gas transmission, geological storage and distribution system to store hydrogen. We have not yet worked on various physical and materials-based storage solutions such as cold- and cryo-compression, hydrides, organic liquids and sorbents.*

c. This is a comment related to hydrogen for transportation. You described SoCalGas interest in hydrogen for HDV, but please don't forget about light-duty vehicles. There are similarities but also differences between the storage requirements for these two applications. Because of cost of both storage tanks and infrastructure, 700-bar pressurized gas is likely not the ultimate solution for storing H2 on LDV; it is also physically impossible to meet the DOE target for volumetric capacity with 700 bar. Consequently, materials-based storage will be essential. Many more fueling stations are needed to make HFCV attractive to the consumer. To achieve that, their cost must be reduced. This can be achieved by reducing the pressure to ~100 bar, which could be possible with some storage materials currently under investigation.

i. *Thank you very much for this detailed comment. We are looking across all vehicle categories regarding hydrogen for transportation. Improving on-board storage and storage for hydrogen in transportation is an area Light Duty, Medium Duty, and Heavy Duty can benefit from. We welcome any research and project ideas in this area.*

d. **Have you interacted with LLNL on quantum hydrogen storage to take advantage of the para/ortho transition?**

   i. *We're certainly interested to hear more. We have not interacted with LLNL on quantum hydrogen storage to take advantage of the para/ortho transition. This quantum mechanics based research appears to be very early stage or theoretical.*

e. **Is there interest in metal hydrides for reversible hydrogen storage?**

   i. *Thank you for the question. We welcome all new research topics and would like to connect directly to discuss further.*

f. **Yes, trying to follow-up on my rail question & your answer. Is the entity that canceled that you mentioned, I believe you said "VE Rail" who is VE Rail, why was it cancelled and what other entities have you considered or might be approached for co-funding?**

   i. *VeRail Technologies Inc. was a company based in Reno Nevada that specialized in locomotive technologies. The original scope was to develop a natural gas switcher locomotive to be demonstrated at Pacific Harbor Line's facility. After a management change, they shifted their focus to battery electric and the project was cancelled. We are currently in discussions with OptiFuel to demonstrate a CNG/Hybrid locomotive. OptiFuel worked with GTI to develop a natural gas locomotive demonstration at Indiana Harbor Belt. And we are currently working with GTI to develop a proposal for DOE funding for a hydrogen fuel cell locomotive demonstration.*

4. Clean Generation

a. **With the expansion of clean production/generation of various 'things' - it seems like this sub-program should include the word Electricity. While other sub-programs would have generation of other things like; H2, RNG, chemicals, etc...**

   i. *Thank you for this input.*

5. Customer End-Use Applications

a. **Hydrogen and RNG integration is specifically called out for the residential and commercial end-use applications but not for the commercial food service (CFS). Is it just assumed that hydrogen and RNG integration will all be applied to the CFS sub program?**

   i. *Yes, but less work has been done on efficiency and emissions in CFS, so that is the priority. Burner design will include incorporating hydrogen blended fuels.*

b. **How do you determine the performance metrics (efficiency gain) for your R&D projects? Is it based on the efficiency needed to be cost effective?**

   i. *We are particularly interested in technologies that provide a step-change increase in efficiency (e.g., gas heat pumps with COP > 1.2). Along with technical feasibility, we characterize commercial feasibility, including cost effectiveness.*

c. **Is the water sector; particularly their downstream biosolids processing, a group that should be considered as a customer end-user or does it fall into another group like industrial? PSS the water group can be a big user of gas for emergency backup.**

i. *Thank you for this question. Biosolids processing that requires large thermal loads would fall under Customer End-Use Applications. Biosolids conversion to fuel would fall under Low Carbon Resources. Technology for on-site power generation or backup power would fall under Clean Generation.*

d. In view of the $20B in Food Processing, consider increasing your % devoted to this of funding; also is carbon capture and re-use at processing facilities included in this program?

i. *Thank you for the comment. Carbon capture and utilization generally falls under Low Carbon Resources. If we identified a CCUS technology specifically integrated with an application, like food processing, it could fall under Customer End-Use Applications.*

e. Can you share any updates or outcomes of the EAC Testing of Hydrogen/NG Blend Impact on Appliances project?

i. *NYSEARCH has developed a model that projects the performance of the in-service appliance population when new gas compositions are supplied (https://www.nysearch.org/apps/gix/). The research under this project incorporated our in-house testing on local appliances into the RANGE program so it would be more applicable to our service territory and to include hydrogen blends. With the added data, the model's predictions for flame characteristics are now consistent with the hydrogen-blend test data.*

f. Will your H2 use in appliances be testing in actual appliances? If so, what are some of the ones that you are focusing on?

i. *There is a large body of research on the impacts of hydrogen blends on end-use equipment, including a recent CEC study conducted at UCI. We are seeking guidance and input from our stakeholders on which sets of appliances need new/additional testing with hydrogen blends. What gaps are in the current research that we could address to advance the concept of hydrogen blended fuels?*

g. What is the highest H2 concentration getting tested for appliances?

i. *There is a large body of research on the impacts of hydrogen blends on end-use equipment, including a recent CEC study conducted at UCI that looked at blends up to 70%. We are seeking guidance and input as to what blends levels would be most appropriate for research? Low blend levels (<10%) are more likely to be operationally feasible in the near term. However, higher blend levels may guide equipment development for future scenarios. What is the best strategy for RD&D to pursue in order to advance the concept of hydrogen blended fuels?*

6. Gas Operations

a. How much interest is there at SoCal Gas for investment into a dedicated hydrogen distribution pipeline from a production source to a large end-user?

i. *Thank you for your question. Infrastructure investments fall outside the scope of the RD&D program. However, we are interested in studying the costs and benefits of dedicated hydrogen pipelines. If there is a case study that could provide information*

regarding the feasibility of dedicated hydrogen infrastructure, we would be interest in learning more. Please reach out the RD&D team via email at RDDInfo@socalgas.com.

b. Gas Operation by blending RNG with NG can be a practical solution to address the limited resource of RNG, (To decrease the GHG emission). Since the quality of RNG varies by upgrading process, and the supply is not constant. By this way increase the economics of RNG production by loosening the upgrading requirement. There will be fuel quality issue on this, But I am suggesting some research projects to enable this approach.

i. *Thank you for this comment. A very good pathway to explore.*

c. How can you accelerate construction and maintenance projects including pipeline integrity?

i. *Thank you for raising this issue. We will take that comment under consideration for future work. This is currently a consideration for the projects we conduct. For example, our pipeline internal inspection program where we are developing additional capabilities to make the processes more efficient and faster.*

d. Difference in the number of projects from 2018 (less than 50) to 2019 (over 150). Why the increase in the number of projects?

i. *Difference in the reporting methodology*

e. Can you identify the sub-program and specifically identify the projects that are associated with methane abatement?

i. *Category: environmental and safety sub-program*

f. The storage facilities – I think we should consider the storage facilities one of the most important assets of SCG's future resources. What I mean by that is energy storage is going to become more important on the era of high renewable use on the electric grid and I think that there is a very important need to study the use of renewable gases in the storage facilities. I'm in particularly interested in renewable hydrogen. There could be other gases that can be considered.

i. *We do have a number of projects going on related to injection of other gases into our storage fields but that's a great comment and we'll take that under advisement.*

Appendix C: Post-Workshop Feedback

Feedback and comments submitted in writing by individuals following the public workshop held on April 24, 2020, are reproduced below in the format they were submitted except that they have been enumerated for ease of citation within the Research Plan document.

Written Submissions

1. Brandon Iglesias
Reactwell, L.L.C.

a. Consider funding research projects that convert carbon dioxide greenhouse gas into hand sanitizer, such that organizations with kitchens and food preparation services that depend upon natural gas to power their cooking appliances can then upcycle the carbon dioxide into hand sanitizer for clean and sanitary food preparation services without increasing the economic burden on their businesses and facilities. Our team has been prototyping a continuous hand sanitizer dispenser based upon our voltanol carbon nanospike material science innovation to address this need. We would welcome the opportunity to help your customer base stay healthy and serve products to help keep them working in clean and safe environments upcycling carbon dioxide. This would be a device that plugs into a wall outlet 15 amp and produces hand sanitizer at point of use in buildings that at times have 100 or so devices, where said facilities management and restocking is an issue of small inventory dispensers. The prototyping work would be performed at LACI in downtown Los Angeles, CA and in New Orleans, LA.

b. Consider funding research projects that convert carbon dioxide greenhouse gas into sanitizer products, bulk basis. Such that large facilities that run HVAC systems and heating systems can upcycle the carbon dioxide emissions into sanitizer for building cleaning and spray treatment. Therefore, reducing their economic burden due to COVID-19 by upcycling a concentrated carbon dioxide source directly into a useful on-site cleaning product that reduces their business costs going forward for safe & clean work environment as well as upcycling carbon dioxide. Our team would welcome the opportunity to help your customer base generate cleaning and sanitization fluids based upon upcycling carbon dioxide and is currently working on a bulk sanitizer based upon upcycling carbon dioxide for building cleaning. We are now in discussions with an NFL stadium owner, hospital system, food preparation site, medical clinic and dentist association. The prototyping work would be performed at LACI in downtown Los Angeles, CA and in New Orleans, LA.

2. Laura Roughton

Hello,

a. I am so appreciative of Lea Peterson's invitation to attend the 2020 SoCal Gas RD&D Workshop. Although I do not have a background in Gas, I am an involved community member and past Mayor and City Council Member in Jurupa Valley. Much of what was shared during the Workshop was over my head you might say, but there was information about your past and forward thinking goals that I found interesting and peaked my curiosity about the world of Gas. I also appreciated the explanation of acronyms throughout the presentation.

b. Just a couple of thoughts:

Written Submissions

c. One of the topics spoken about had to do with equity and inclusion specifically with disadvantaged communities (DAC). During my time on City Council, I served on the OWOW (One Water One Watershed) Steering Committee under SAWPA (Santa Ana Watershed Project Authority) during their most recent Plan update. There was a working group with special funding allocated that addressed DAC and developed strategies during our Plan update. I think you would receive beneficial information by contacting Rich Haller at SAWPA for details.

d. There was a question asked about other groups to speak with. Depending which area/s you want to share, I suggest any of the COG'S (Councils of Governments) such as WRCOG, SBCOG, etc. Of course SAWPA as I mentioned above and any of their appropriate sub-committees. And then for things in the area of Customer end-use or even exciting developments in the world of Gas, I suggest speaking at Chamber of Commerce meetings or possibly even Rotary or Lions Club meetings. These are places where you will find you local leaders who can then share the information in their public circles. Jurupa Valley as well as other cities have a Healthy City Initiatives. Healthy Jurupa Valley holds a monthly collaborative meeting as well as five community-led Action Teams meetings which would be good opportunities to share your message and cutting edge projects. I was surprised by how many different areas your are involved with and I think others would be as well.

e. I'll be honest. I was only going to tune in to the first session of the Workshop to get an overview but it was interesting to me even as a lay person and I stayed on pretty much through the whole event.

f. Thank you for providing a resource that we take for granted every day and for allowing me to learn more about the world of Gas.

Sincerely,
Laura Roughton

3. Daphne D'Zurko
Executive Director, NYSEARCH
Vice President, RD & D
Northeast Gas Association

To Whom It May Concern:

a. As a partner and collaborator with SoCal Gas' RD & D department, I wanted to provide feedback for SoCal Gas related to the 2020 RD & D Workshop that I attended last Friday April 24.

b. Our (21) members in the voluntary NYSEARCH RD & D collaborative that service LDCs in N. America and our NYSEARCH Staff agree that SoCal Gas R & D Staff and their integrated Subject Matter Experts have lead the industry in many areas of innovation and best practices that come from a robust R & D program.

c. In particular, they have led many design, development and research data assessments and have hosted and critiqued many important live field tests for several of our NYSEARCH programs going back to the early 2000s.

d. Just focusing on the last few years, SoCal Gas has been a leader in the areas of pipeline inspection/integrity and has been a key stakeholder and leader for the commercialization of our EXP series of Robotic Inspection Platforms and related sensors and enhancements (such

Written Submissions

as Energy Harvesting which was featured in their 2020 report). Also they have lead or have provided key feedback in projects that improve Safety or work toward reduction of emissions and low carbon/de-carbonization. Examples of safety-related projects are Non-Destructive Evaluation of Plastic Pipe materials and innovative PE Pipe Location projects. Further, as the greater industry moves toward what SoCal has been working on in de-carbonization, they are helping to lead discussions now in renewable energy projects. For our collaborative, we have new and ongoing projects that particularly address emerging RNG technologies or issues for LDCs in this space.

e. We value our relationship and applaud SoCal's RD & D staff and diverse program portfolio.

f. We look forward to continued collaboration.

4. Praveen Cheekatamarla
Oak Ridge National Lab

a. The webinar was quite interesting and informative! It gave a good overview of the full breadth of RDD areas SoCalGas is looking at.

b. Here are some quick thoughts and feedback on additional RDD areas

   i. Previously I worked with major upstream and midstream gas companies and one of the major observations was the methane leak during operations. Methane abatement was big on radar (4 years ago) and I believe that is still one of the major concerns associated with natural gas. Fugitive methane from pneumatic controllers was a major contributor for which a low cost gas fired power generation device was sought. EPA estimates ~48BcF of Methane release annually

   ii. We work with a food service equipment manufacturer on a project. In our preliminary discussions, it seems like there is lot of opportunity in decreasing the stand-by load as well as emissions suppression.

   iii. Waste heat utilization via thermo-chemical energy storage or electric power generation

   iv. Source CO2 capture and conversion to value added chemicals

   v. Utilization of solid carbon (generated from pyrolysis of natural gas) for battery electrodes

5. Daniel S. LeFevers
Director, State and Consumer Programs
Gas Technology Institute

a. The Gas Technology Institute (GTI) strongly supports SoCalGas' proposed 2021 research, development and deployment (RD&D) program, as outlined in the April 24, 2020 workshop. The RD&D program provides substantial benefits to California energy consumers through the development and testing of new technologies that improve efficiency, reduce emissions, address climate change, and support energy system safety, reliability and resilience while also ensuring continued reasonable energy costs to consumers.

b. Specifically, the redesign of the program, which increases focus on reducing GHG emissions to address the climate goals of California through program areas including Low Carbon Resources, Clean Transportation, Clean Generation and Customer End-Use Applications, are setting the standard for natural gas utilities throughout the country, creating and testing new technologies, and leading the way to a new low carbon energy future.

Written Submissions

c. The addition of renewable and low carbon gases into the natural gas system through deployment of technologies like power-to-gas, and the repurposing of waste CO2 will be critical to reaching the State's decarbonization goals. SoCalGas through their RD&D program is developing the techniques, testing, and technologies to ensure that the use of cleaner lower carbon gases and elimination or reuse of CO2 will be safe and affordable. The existing gaseous storage 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".

d. 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 many other research organizations in, and outside of California. This coordination leads to leveraged funding and 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. 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.

e. SoCalGas is also in a unique position to understand the integration of renewables and low carbon gases into the gas distribution system and how technologies like hybrid gas/electric equipment and solar can augment homes and businesses to reach zero net energy status. Understanding how to use the natural gas system to deliver a low carbon energy future will be the cornerstone of California reaching its GHG reduction goals. The SoCalGas RD&D program is designed to deliver the 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.

f. 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 leak detection are important to ensure California's natural gas infrastructure can deliver lower carbon results for energy consumers. A robust SoCalGas managed RD&D program focused, in part, 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 SoCal Gas 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.

g. 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. Most of these engines being operated in California today, are now fueled with renewable natural gas (RNG). This results in major reductions in conventional criteria pollutants like NOx and PM 2.5 along with substantial reductions in GHG emissions over their diesel and gasoline counterparts.

h. GTI continues to support and value the SoCalGas RD&D program and we look forward to participating as a performer, co-funder and augmenter of the program. GTI believes that the SoCalGas RD&D program is critical to meeting California's energy, economic and environmental goals and to providing benefits to California's energy consumers.

Written Submissions

6. Crystal Yeh
Pearlie Sabino
Regulatory Analysts
Public Advocates Office – ECOSNG Branch
California Public Utilities Commission

a. The participants from the Public Advocate Office respectfully make the brief comments on the above RD&D Workshop below:
b. The RD&D Program Workshop lacks information on how it decides on the Funding Allocation across the 5 main Programs, including the amount spent on Management/Administration. The information provided in the Workshop indicates that the 2019 spending had the following breakdown: 6% on Admin, 27% on Gas Operations, 39% on Low Carbon Resources, 14% on Customer End-Use, 6% on Clean Generation, and 8% on Clean Transportation. Further, for the years 2020 and 2021, the Workshop indicates that the funding allocation will be: 10% on Admin, 22% on Gas Operations, 33% on Low Carbon Resources, 13% on Customer End-Use, 10% on Clean Generation, and 12% on Clean Transportation. However, no information was provided on the decision criteria to arrive at the funding allocation to enable the participants to determine the appropriateness of the allocations made. It is suggested that the RD&D program be more transparent on how it arrives at the program funding allocation from year to year and whether it is the RD&D program administrator who decides the funding allocation.

7. Renee Guild
Senior Analyst, Gas Policy & Reliability, Energy Division

a. Why did SoCalGas' 2019 spending decrease from your forecast approved in Sempra GRC 19-09-051 from $14.329 million to $13.142 million?
    i. Which sub-program areas were decreased?
    ii. Where is the $1.187 million difference being utilized or accounted for?
    iii. Why was the total authorized budget not utilized?
b. Why did spending for Customer End-Use Applications decrease from 16% of SoCalGas' budget in 2018 to 14% in 2019 and 13% in 2020?
c. In 2018, SoCalGas' spending on "Program Wide Partnerships" was $2,702,278 or 21% of your budget. You explained in the workshop call that these partnerships had been allocated to the various research projects in which you participate as part of the research consortiums you are part of and are no longer separately identified in your budget or in the 2019 Report. For each of these consortiums, (GTI, PRCI, NYSearch, UCI Clean Energy Research Center, etc.) please identify the total amount of your 2019 and proposed 2020-2021 budget you are spending with these partnerships and which projects they are supporting, with the amount of your contribution for each project, as you identified in the 2018 Report.
d. The new sub-program headings seem helpful; please reflect them in the headers on each page of the 2020 Report's Appendix, as they were in the 2018 Report. They are not so displayed in the 2019 report.
e. Please identify which projects are specifically related to your methane abatement efforts in the Gas Operations section of your 2020 & 2021 RD&D proposed budgets and which Best

Written Submissions

Practices in SoCalGas' and SDG&E's 2020 Leak Abatement Compliance Plans they are intended to affect.

f. Methane capture and other technologies that reduce utilization of NG via renewables or energy efficiency at food processing facilities is important, given that food processing is a major industry in California. Increasing funding for such projects should be considered.

g. There were several excellent points made by the representatives of UC Irvine who spoke during the workshop that bear emphasizing:

   i. Since SoCalGas' role in increasing the utilization of renewable gas into the system is critical, the balance of RD&D funding between integration of renewable gas and distributed generation seemed to be on the high side for DG (3/4) and not enough for integration (1/4).

   ii. Additionally, the overall funding for these two categories seems small at $2 million.

   iii. Research into how storage facilities can accommodate hydrogen should be a priority for SoCalGas, given its large storage resources.

h. The "Go to Meeting" technology did not allow participants in the workshop to easily contribute their thoughts and remarks. I was frustrated not to be able to be heard at several points in the workshop and also to not hear others who had their hands raised, such as Laurie ten Hope and others at the CEC. While it's understandable that you may have not had much practice in using such platforms, in future, please do some test-runs with outside participants to make sure everyone can easily participate and the moderator is able to smoothly run the meeting.

i. A more detailed agenda with proposed sub-funding and sub-program levels should be provided before the workshop so that participants can comment with more preparation on the proposed allocations of spending. That being said, getting the 2018 and 2019 Reports out in the first quarter as well as orchestrating this workshop on the 2020-21 program early into the second was a big effort and it is much appreciated.

j. Given the complexity of the material, the length of the workshop was about right

8. Paul Grimmer
President
Eltron Research

a. We have a number of programs in various stages of development that could fit well with SoCalGas' objectives of providing cleaner gaseous fuels for your customers.

b. Ethane to Aromatics – As Jack had indicated, we have a patent pending process that converts ethane into aromatics. Alost all ethane is contained in natural gas, and on a weight basis can be as much as 30% by mass of the total gas stream. Since the late 60s companies have been extracting ethane and using it to make ethylene but even with massive ethylene expansion in the past 5 years, the growth in natural gas supply has outstripped the demand for ethylene and now about 500,000 bpd of ethane is being left in the natural gas streams. On the other hand, aromatics are used in multi-million bpd quantities in the chemical industry and also as an octane enhancer in gasoline. Essentially all aromatics come from crude oil so making them from natural gas will help reduce oil consumption while at the same time making much better use of the ethane than leaving it in the natural gas stream.

Written Submissions

c. On a weight basis aromatics are worth about 6 times as much as ethane so there is a very large economic driver to do this. In addition, there are places in the world such as the north slope of Alaska where we could get aromatics out via the existing, underutilized oil pipeline whereas the methane will likely never come to market. Just that one field has 1.7 billion barrels of ethane and propane that could be converted to aromatics and shipped to the West Coast that will otherwise likely stay in the ground forever. We have this technology to the point of scale-up.

d. Superacid - We have invented a new superacid that is about 1 million times stronger than 100% sulfuric acid and is contained inside of porous supports like zeolytes (you can hold it in your hand). This catalyst will have many other applications but the effect on methane alone will be significant. It is strong enough to break the C-H bonds in methane. Combined with a hydrogen membrane we believe we can disproportionate the methane and make iC4 – iC7 along with purity hydrogen. This technology is still at the discovery and proof of concept stage. We have patent applications in covering composition of matter and manufacturing methods.

e. Hydrogen Membrane Separator and Pump – We had been developing a metallic hydrogen membrane with the DOE until the Obama administration decided to halt R&D for coal (NETL was co-funding us). Our membrane is 100% selective to H2. Rather than using IGCC with carbon capture in a coal-fired power plant to provide a syn gas stream where we could extract H2, we believe there are a couple of different applications that are much better.

f. One problem with any membrane-type H2 separation device is that there needs to be a significant partial pressure differential to provide the motive force for the H2 to go through the membrane. This makes ow pressure separation difficult, especially when the permeate side is 100% H2. It has been shown with PEMs that by applying a voltage across the membrane, we can get the separation to occur even if the permeate pressure is much higher than the inlet pressure. Unfortunately, the operating temperature limit for PEMs makes them impractical for industrial use. Our metallic membrane does not have those limitations. So we have a hydrogen separation device with 100% selectivity combined with a no-moving-parts pump/compressor.

g. Here are a few applications for this type of system. At a hydrogen fueling station, this could replace the expensive hydrogen compressors that must be used to pump hydrogen to as much 10,000 psi for transfer to vehicles. In fact, we could likely do it on-the-fly and get rid of the ultra high pressure storage tanks at the “gas” station.

h. There are many low pressure industrial reactions that make hydrogen that they need to get out of the reactants. An example is a steam methane reformer. Not only could we remove the H2 (and nothing else) but we can do it in the reactor. This shifts equilibrium and allows the reaction to proceed to completion without the need for recycle or many reactors in series. These continuous membrane reactors can be used in many dehydrogenation reactions including ethane to ethylene, propane to propylene, benzene to ethylbenzene and then styrene, etc.

i. BTW, this system inherently provides CO2 capture because the H2 goes through the membrane, leaving the CO2 and everything else non-H2 in the retentate.

Written Submissions

j. We have spent over $25 million since 2002 on development of our hydrogen membrane. It works well; the program it was funded through was halted and we would very much like to transition it to non-coal use.

k. Hydrogen Separator & Fuel Cell – Suppose we take the metallic membrane described above and we put a proton conducting ceramic on the back. Electrons would have to flow around the membrane to be combined with protons on the other side. This becomes not only a 100% selective hydrogen membrane but also a very simple and efficient fuel cell.

l. We have been around since 1982. WE have done over 330 Phase I and II SBIR projects but I am more interested in doing non-SBIR projects that we can get to market. I would very much like to discuss collaboration on any of these with you.

9. Jonah Steinbuck, Ph.D.
Manager, Energy Generation Research Office
California Energy Commission

(Note the following feedback from Jonah Steinbuck includes responses to SoCalGas's stakeholder questionnaire. The parts from the questionnaire are shown in ***bold italic*** text with responses following each in normal and enumerated text.)

a. CEC Energy Research and Development Division (ERDD) staff appreciate the opportunity to provide comments on plans for the SoCalGas RD&D Program.

b. For background, the CEC's Natural Gas Research and Development program enables the natural gas sector to support California's energy and environmental goals by accelerating technology innovation. Specifically, the program seeks to: reduce vulnerabilities and fugitive methane emissions in the natural gas infrastructure; improve the cost-competitiveness of renewable gas; and improve the energy efficiency and air quality profile of natural gas end uses. California is currently charting a path towards decarbonization to achieve the state's goals of statewide carbon neutrality and a 100% zero-carbon electricity system by 2045 (EO B-55-18; Senate Bill 100, de León, Statutes of 2018). While electrification is a key strategy to achieve these state goals, the natural gas sector continues to play an important role in meeting the state's objectives for reducing carbon emissions, increasing energy efficiency, and safeguarding health and safety.

c. SoCalGas' RD&D program can complement the CEC's R&D efforts to help meet the state's clean energy goals. For example, SoCalGas is well-positioned to support pilot demonstrations of hydrogen blending in the natural gas pipeline. This is an area of interest for the CEC and one that depends on close collaboration with utilities, including SoCalGas. As another example, the SoCalGas RD&D program can provide a deeper look at fugitive emissions upstream of customer meters, complementing the CEC's behind-the-meter focused research. Additionally, both CEC and SoCalGas have important roles to play in ensuring the safety and integrity of natural gas infrastructure, including through the development of technologies that improve monitoring of infrastructure condition and performance.

d. Historically, the CEC has successfully partnered with SoCalGas on projects spanning residential and commercial end use appliances, industrial process energy improvements, and transportation with high- efficiency low-emission CNG heavy-duty engines. These collaborative projects have delivered important deployments (e.g., Hyperlight, GTI on food processing) and commercialization achievements (e.g., Cummins Westport).

Written Submissions

e. Additional CEC staff comments are provided below to further our collaboration and the complementarity of our respective programs.

(Begin Stakeholder Questionnaire Responses)

INTRODUCTION

As you may know, the SoCalGas RD&D Program identifies and supports new technologies and research activities that benefit customers through improved reliability and safety, environmental benefits and operational efficiencies.

The RD&D Program supports research across the natural gas supply chain:

- ***Low Carbon Resources RD&D – Decarbonizing the gas supply***
  - ***Renewable natural gas***
  - ***Hydrogen***
  - ***Carbon Capture, Utilization & Sequestration (CCUS)***

    f. CEC ERDD Staff: A significant focus on decarbonization, including low-carbon resources, is a top priority to meet the state's goals for addressing climate change.
- ***Gas Operations RD&D – Improving pipeline system safety and reliability***
  - ***System design & materials***
  - ***Inspection & monitoring***
  - ***Environmental & safety***
- ***Customer Solutions RD&D – Reduce emissions & increase efficiency for natural gas customers***
  - ***Clean heat – appliances and industrial***
  - ***Clean generation – electricity generation***
  - ***Clean transportation – vehicles and off-road equipment***

RESEARCH PLAN

The 2019 General Rate Case (GRC) Decision placed additional reporting requirement on the SoCalGas Research, Development & Demonstration (RD&D) Program:

"… SoCalGas should host an annual workshop during the second quarter of 2020 and 2021 under supervision of the Commission's Energy Division. At these workshops, SoCalGas should present the result of the previous year's RD&D program and obtain input regarding its intended spending for the following calendar year."

"The research plan should (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 (3) discuss how SoCalGas incorporated feedback from workshop stakeholders and Commission staff."

INPUT

We need your input to help guide funding allocation for the 2021 calendar year. The questions below are intended to begin a discussion and collect your input and expertise. The Momentum team will be collecting and synthesizing your comments into a guidance document for the RD&D Research Plan team.

DISCUSSION QUESTIONS

Written Submissions

- ***Technical Areas: Low Carbon, Gas Operations, Customer Solutions:***
  - ***What technical questions are most pressing from a research standpoint?***
    - g. CEC ERDD Staff: How to effectively support the state's decarbonization goals through technological solutions, including clean hydrogen, renewable gas, and reduction of fugitive emissions.
    - h. CEC ERDD Staff: How to speed advancement of clean hydrogen technologies
    - i. CEC ERDD Staff: How to drive cost reductions and facilitate integration of higher blends of renewable gas
    - j. CEC ERDD Staff: What are the full fuel cycle impacts of renewable gas, including production, transmission, distribution, and end-use
    - k. CEC ERDD Staff: What are the emissions, durability, and performance impacts to natural gas vehicle engines with blends of hydrogen. Recommend adding CEC staff to the TAC of existing SoCalGas project with UCR.
  - ***What gaps or significant needs do you see in one or more of these categories?***
    - l. CEC ERDD Staff: Identification and mitigation of fugitive emissions from storage and distribution, complementing CEC's behind-the-meter focused research
  - ***What pain points must be addressed for natural gas customers?***
    - m. CEC ERDD Staff: Low income energy burden
  - ***Top three research priorities?***
    - n. CEC ERDD Staff: Key priorities include decarbonization, air quality, affordability, and resilience
- ***SoCalGas RD&D Program***
  - ***What is your overall assessment of the SoCalGas RD&D Program?***
  - ***What are the key policy drivers that SoCalGas RD&D should consider?***
    - o. CEC ERDD Staff: SB32, EO B-55-18, SB100
  - ***How is the SoCalGas RD&D Program differentiated (or how should it be) from other RD&D programs (CEC, DOE, etc.)?***
    - p. CEC ERDD Staff: As a utility R&D program, there are opportunities to leverage connections with end-use customers to facilitate adoption of advanced technologies funded through this and other R&D programs.
  - ***What does the SoCalGas program bring/offer that others cannot***
    - q. CEC ERDD Staff: The opportunity to demonstrate RD&D leadership on decarbonization for an all-gas IOU, providing a model for other all-gas IOUs across the country.
- ***Other Questions:***
  - ***What customer segment (Res/Comm/Ind) needs additional support from RD&D?***
    - r. CEC ERDD Staff: Low income and disadvantaged communities
  - ***How should SoCalGas consider ongoing RD&D focused on decarbonization?***

Written Submissions

s. CEC ERDD Staff: Consider advancing replicable decarbonization solutions in industrial applications where replicability is more challenging (given wide variations in equipment and processes)

- ***Other strategic points for SoCalGas's RD&D program?***
  t. CEC ERDD Staff: Establishing pathways to market adoption for emerging technologies
  - ***What else should SoCalGas consider to strengthen its RD&D program?***
  - ***Other Contacts***
  - ***Who else should we talk to?***
  - ***Other Comments***
    u. CEC ERDD Staff: Delivering hydrogen through the existing natural gas pipeline network has been proposed as a promising strategy to increase the percentage of renewable energy and help decarbonize our natural gas system. To facilitate this, it will be important to develop hydrogen blending standards, deployment strategies, and interconnection requirements that are tailored for California's gas system. The proposed research work on blending and interconnection standards can complement CEC's work on deployment and demonstration, supporting adoption of hydrogen technologies --including hydrogen generation from renewable energy resources and customer end-use appliances.

    v. CEC ERDD Staff: The CEC funds work on the impacts of climate change on natural gas infrastructure. This is an area that can continue to benefit from collaboration. SoCalGas' input on information needs for planning can continue to inform this work. We welcome further engagement and discussion on this topic.

    w. CEC ERDD Staff: CEC wants to emphasize the importance of addressing equity and environment goals. This is a core focus for the CEC as we accelerate progress toward cleaner energy delivery and a low carbon economy. The CEC would offer two resources for your consideration:

    x. (1) the CEC's Empower Innovation platform. This is a new resource for the state's clean energy research programs, researchers, and community organizations. It provides access to funding opportunities – both in the form of grants and venture investment. Anyone can utilize the platform and add a profile to share organizational needs or available funding for projects.

    y. (2) CEC has revised its grant selection criteria to increase benefits to underserved communities. The criteria were developed with input from environmental justice organizations.