SoCalGas A Sempra Energy utility®

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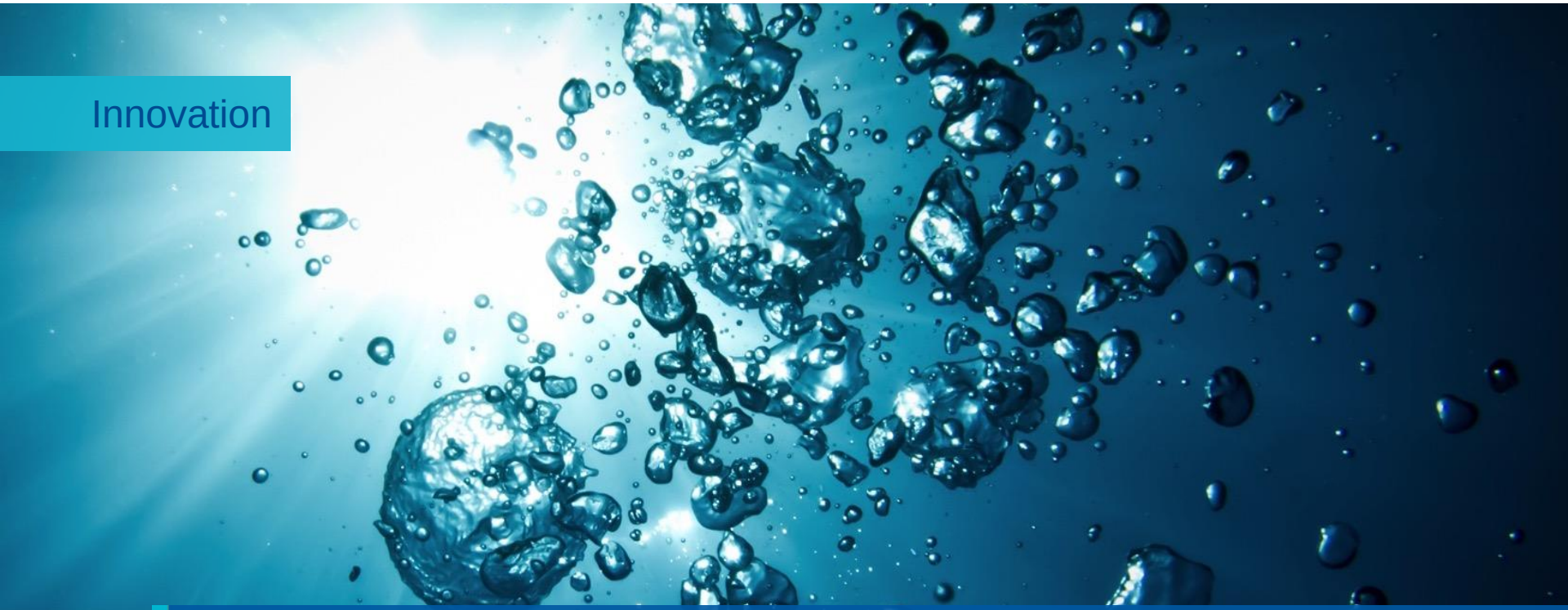


Innovation

2020 WORKSHOP

Research, Development, & Demonstration (RD&D) Program

April 24, 2020

Meeting Notes

- Each session concludes with time for questions and comments. **There will be a dedicated 30-minute session at the end of the day** for questions and comments not addressed earlier.
- The recording will be made available after the workshop
- Workshop registration link: https://attendee.gotowebinar.com/register/5145566390058790414
- Please submit questions and comments in the GoToMeeting questions box.
- If you would like to make a comment verbally, please raise your hand in the GoToMeeting controls. If called upon, we are limiting responses to one minute.
- Participants are encouraged to provide written comments after the workshop. **Written comments should be submitted by Friday, May 1st** to RDDinfo@socalgas.com.

Presentation Objectives and Structure

Provide results from 2019

I. RD&D Overview and Structure

II. 2019 in Review

Give an update on 2020

III. Status and Changes for 2020

Seek input for 2021

IV. RD&D Plan Development

V. Low Carbon Resources

VI. Clean Transportation

VII. Clean Generation

VIII. Customer End-Use

IX. Gas Operations

Agenda

	Start Time	Duration (mins) Total *(presentation/Q&A)*	Topic
Section 1 90 mins	9:30am	60 mins *(45 pres. + 15 Q&A)*	Overview, Status, & Updates (I. → IV.)
	10:30am	30 mins *(15 pres. + 15 Q&A)*	Low Carbon Resources (V.)
	11:00am	**15 mins**	**BREAK**
Section 2 60 mins	11:15am	30 mins *(15 pres. + 15 Q&A)*	Clean Transportation (VI.)
	11:45am	30 mins *(15 pres. + 15 Q&A)*	Clean Generation (VII.)
	12:15pm	**45 mins**	**LUNCH**
Section 3 95 mins	1:00pm	30 mins *(15 pres. + 15 Q&A)*	Customer End-Use Applications (VIII.)
	1:30pm	30 mins *(15 pres. + 15 Q&A)*	Gas Operations (IX.)
	2:00pm	35 mins *(5 pres. + 30 Q&A)*	Wrap-up + Q&A
	2:35pm		**ADJOURN**

I. RD&D Overview

SoCalGas

A Partner in the fight against climate change

The RD&D Program supports this fight through cutting edge innovation and technology development.

The RD&D VISION is to foster breakthrough innovation for clean energy technology.

The RD&D MISSION is to develop energy solutions that are affordable, reliable, and increasingly renewable.

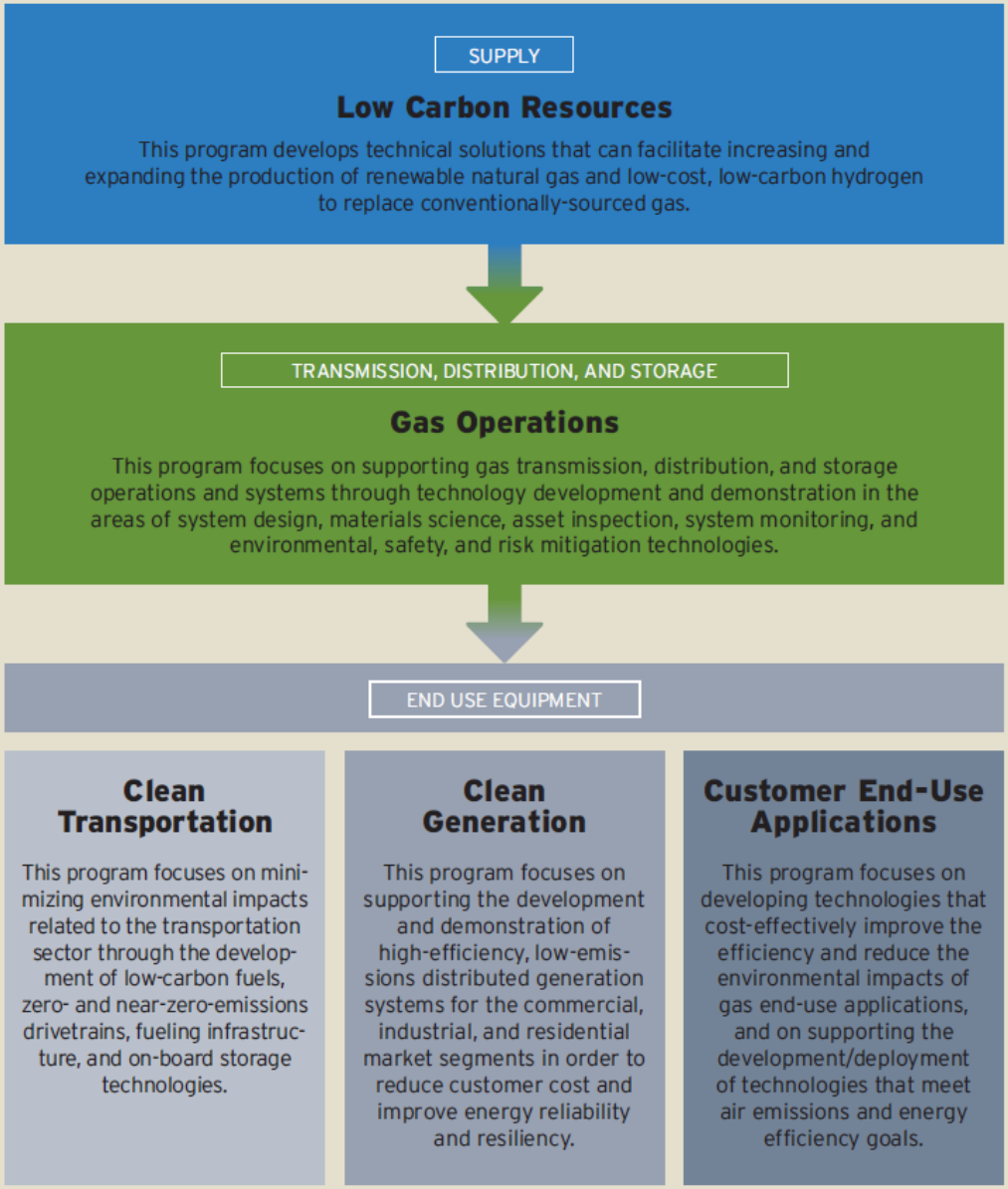
RD&D GOALS

Identify, test, and develop new products and technologies for the gas delivery system that:

- Reduce GHG emissions
- Maintain or improve safety and reliability
- Increase the affordability of energy

RD&D

Program Areas



How do we get there?

To best achieve these goals and to select projects with the best chances of having an impact, the RD&D Program:

- Utilizes **significant resources and capabilities**
- Implements a **rigorous project selection process**
- Leverages **complementary and supplementary programs**
- Fosters **key collaborations**

Significant Resources and Capabilities

Resources	Capabilities
• SCG is the Largest US gas distribution utility with more than 21 million customers • Large list of collaborators	• Expertise in energy, environmental policy, project management, industrial engineering, chemistry, pipeline design, biofuels, and more

Differentiator

Broad expertise, combined with access to the needs of suppliers, vendors, and end-users provides the RD&D team with a unique perspective.

Rigorous Project Selection

PUC 740.1 Guidance

- Provides guidance for project selection
- Select projects where a customer benefit is reasonably probable
- Minimize unnecessary duplication of efforts by other research orgs

RD&D Program Criteria

- Strong team with access to facilities & resources
- Opportunity to leverage outside funding
- Research aligns with RD&D priorities
  - E.g. Policy drivers, corporate drivers, & feedback process
- Affordability to rate payers, especially today

Rigorous Project Selection

Value to Ratepayers

- SoCalGas is an operating utility with access to a diverse set of market participants, both up- and down-stream of their operations.
- RD&D can prioritize projects based on real-time inputs and opportunities to provide value to existing and future customers

A Nimble Process

- Rolling admissions for funding promising ideas and developing new projects as they arise
- Develop and maintain a growing pipeline of potential projects and collaborators
- Identify opportunities to complement and supplement outside efforts

Complementary and Supplementary Programs

Amplify

Build momentum for successful projects to ensure eventual commercial success.

Leverage

Identify opportunities to co-fund RD&D projects and/or build collaborations to fully fund large projects.

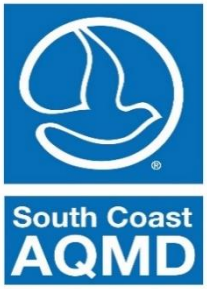
Target Gaps

SoCalGas RD&D funds projects at every stage of development and can do so where gaps exist in other funding opportunities or R&D programs.

Key Collaborations

CARB

gti®



UC Irvine

UCLA

UCDAVIS

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Voices From the Lab

SCAQMD

- Joe Impullitti, Program Supervisor, Technology Advancement Office

National Renewable Energy Laboratory (NREL)

- Kevin Harrison, Ph.D., Senior Engineer

Gas Technology Institute (GTI)

- Ron Snedic, SVP, Corporate Development
  - President, OTD
  - President, UTD

South Coast AQMD Technology Advancement Office

- Established in 1988
- Co-Funds Projects to Develop, Demonstrate, and Commercialize Clean Air Technologies
- Program Organization:

Tech. Implementation

- Incentives
- Commercial Tech.
- Contact: Vicki White (vwhite@aqmd.gov)

Tech. Demonstrations

- Research
- Development
- Demonstration
- Deployment

>100 on-going projects

Contact: Joseph Impullitti (jimpullitti@aqmd.gov)

Key SoCalGas-South Coast AQMD Clean Air Partnerships

Natural Gas ICE Projects

- **CWI:** 8.9 & 12 liter certified low NOx engine
- **Ford:** 7.3-liter Low NOx engine for Class 4-7 trucks (Agility & Landi)
- **WVU:** Comprehensive NGV maintenance cost study

Advanced Natural Gas Vehicle Demonstrations

- **Southwest Research:** 5.4L CNG Isuzu engine demonstrated in a hybrid electric medium-duty truck in partnership with DOE
- **BAE/Kenworth:** CNG range extender drayage truck with catenary (ZECT II) in partnership with DOE

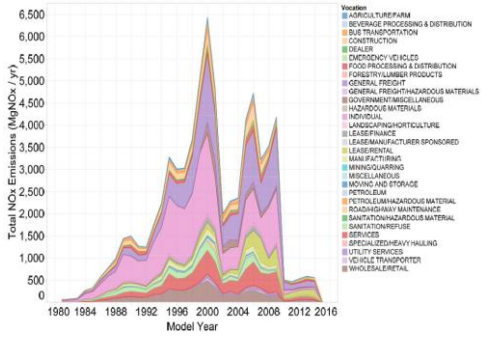
Fuel and Emissions Studies

- **UCR/WVU:** 200 vehicle in-use emissions study in partnership with CEC and CARB
- **UCR:** Assessing emissions impact of hydrogen-natural gas fuel blends

Key SoCalGas-South Coast AQMD Clean Air Partnerships

Studies/Research/Demonstration

- **NREL/Ricardo ComZEV:** technology and economics roadmap for adoption of advanced ZE and NZE commercial vehicle technologies
- **KORE Infrastructure:** Pyrolysis/Thermochemical conversion of organic solids to syngas and renewable transportation fuels, e.g. RNG and RH2
- **UCR RNG Center:** Study RNG potential in California via Thermochemical technologies and Power-to-Gas potential
- **CNGVP (CA NGV Partnership):** Advancing information and the role that natural gas vehicles play with respect to fuel security, air quality, and renewable, low carbon intensity transportation
- **UCI**: Assess the Emission Impacts of Renewable Fuel Blending in the Natural Gas System



UCR College of Engineering- Center for Environmental Research & Technology

UCI University of California, Irvine

California Natural Gas Vehicle Partnership

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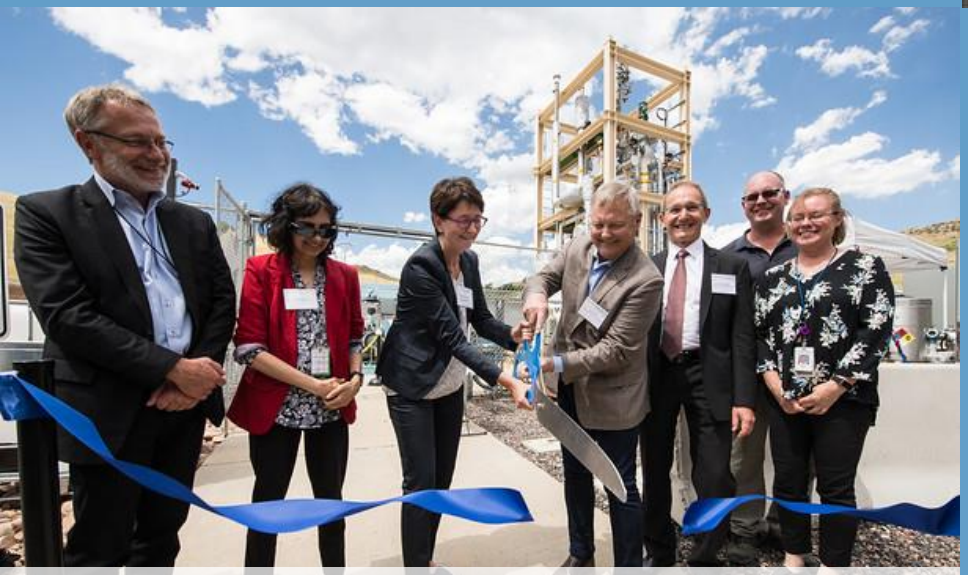
Producing RNG by Recycling CO_2 from Biogenic Sources

- First-of-its-kind pressurized bioreactor in the United States
- SoCalGas, Electrochaea and NREL
- *by Kevin Harrison, NREL*

Bioreactor located at NREL in Golden, CO



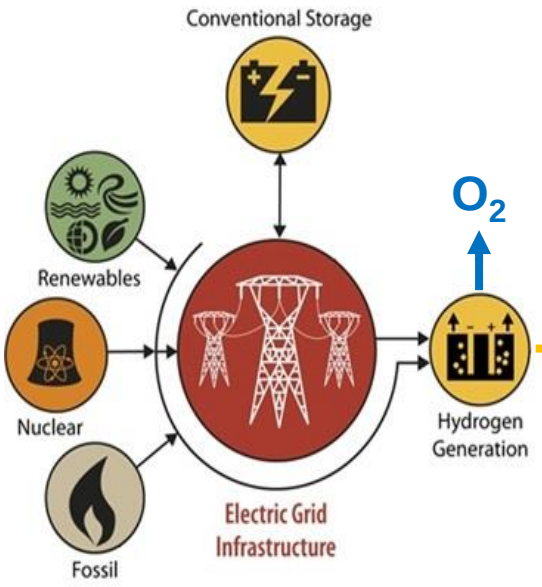
8/13/19: Bioreactor dedication ceremony

The National Renewable Energy Laboratory (NREL) is transforming energy through research, development, commercialization, and deployment of renewable energy and energy efficiency technologies.

Two-step biological process to produce RNG

1) Produces hydrogen (H_2) from renewable electricity and water
2) Micro-organisms convert H_2 + CO_2 -> RNG

Electricity Network



H_2

NG Network

RNG is a drop-in replacement meeting pipeline quality standards

BIOMETHANATION REACTOR

CO_2 Supply

CO_2 Waste Streams

Benefits of Power-to-RNG

- **Enables more wind and solar energy production**
- **Recycles CO_2**
- **Decarbonizing NG network**
- **Drop-in replacement fuel that utilizes existing NG network**

"SoCalGas is a pioneer in power-to-gas technology and have accelerated the science of CO_2 utilization with their investment. And other utilities and stakeholders have noticed."

-- *Nancy Dowe & Kevin Harrison, NREL*

GTI: 79-Year History of Turning Raw Technology into Practical Energy Solutions

FOR A STRONG ECONOMY AND A CLEANER ENVIRONMENT

SUPPLY ▶ CONVERSION ▶ DELIVERY ▶ UTILIZATION

RESEARCH & DEVELOPMENT | PROGRAM MANAGEMENT | TECHNICAL/ ANALYTICAL | CONSULTING | TRAINING | COMMERCIALIZATION | 400+ EMPLOYEES

World-class RD&D facilities headquartered in Chicago area

Ron Snedic, SVP Corporate Development GTI & President OTD/UTD
April 24, 2020

OTD and UTD – Collaborative RD&D Organizations
Identify, Select, Fund and Oversee Research Projects

Membership spanning coast to coast, urban, suburban and rural systems – supporting more than 60 million gas consumers

Stand-alone, 501c(6) not-for-profit, member-controlled companies where gas utilities work together to develop technology solutions to common issues

- Over $12 million in annual dues
- 27 utility members

www.otd-co.org

OTD Operations Technology Development

Est. 2003

- Over $5 million in annual dues
- 20 utility members

www.utd-co.org

UTD Utilization Technology Development

Est. 2004

Why Collaborative RD&D Programs?

Address consumer and member needs including:

- Safety
- Environmental
- Affordability
- Efficiency
- Resiliency

- Highly cost effective by leveraging member, state and federal funding sources.
- Members drive RD&D agenda and influence product/process development to address the needs of their consumers.
- Leverages collective intelligence and experience of member company experts to develop the best possible solutions.
- Provides opportunity for field demonstrations within member's service territory, enabling acceptance by utility personnel, consumers, channel partners, trade allies and regulators.
- Positions member utility to become an early adopter of new technologies and efficient processes.

II. 2019 Year in Review

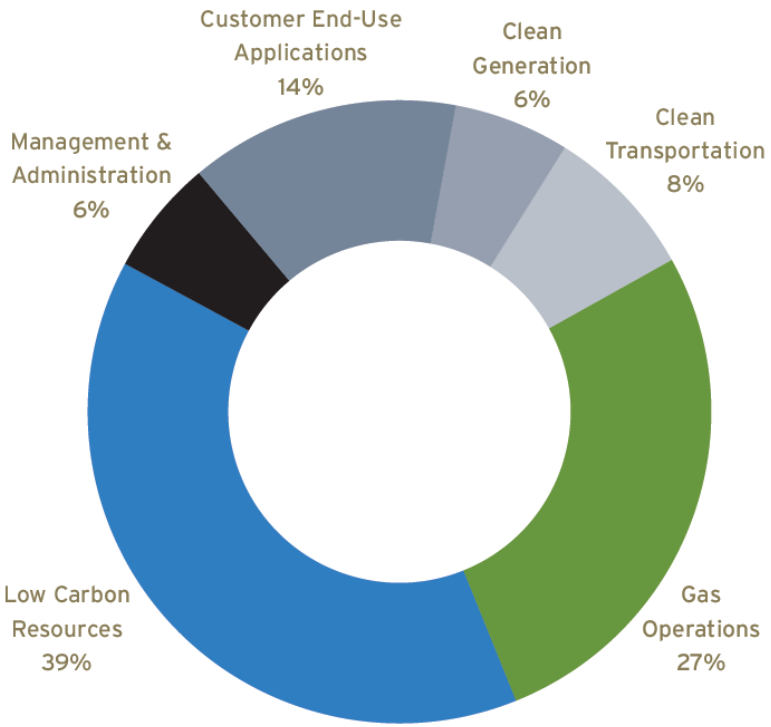
"In 2019, we partnered with research facilities, universities, national labs, and entrepreneurs to support more than 300 RD&D projects in California and beyond. Our investment helps these organizations develop innovative technologies that can lower GHG emissions, improve air quality, and increase the safety of our state's gas networks."

~Maryam Brown, President SoCalGas

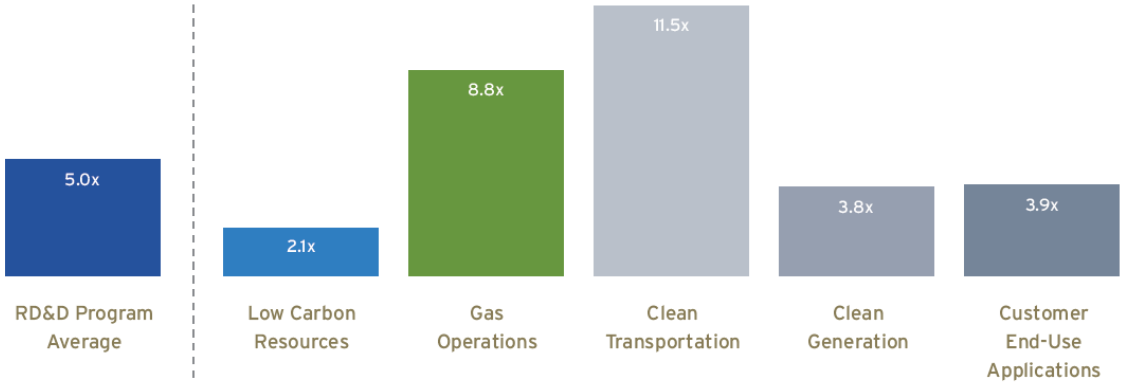
2019 Highlights

$13,142,010
In spent funds

2019 FUNDING ALLOCATION BY PROGRAM AREA AND ADMINISTRATIVE COSTS



RATIO OF OUTSIDE FUNDING TO SOCALGAS FUNDING



Spotlight Projects

Reducing GHG emissions | Improving air quality | Safety

Reliability | Improving affordability/cost reduction

SPOTLIGHT

Low Carbon Resources

Project Team
Genifuel

Hyperlight Energy

California Energy Commission

Harnessing the sun to create carbon-negative fuel

Waste-to-energy system uses novel concentrated solar power technology to convert dairy manure into RNG

The RD&D Program supported the design, fabrication, installation, and operation of a small-scale, waste-to-energy bioenergy system integrating a hydrothermal processing system from Genifuel and a concentrated solar power technology developed by Hyperlight Energy.

Results:

- Extracted ≤80% of the energy in the dairy manure in far less time than a digester
- Produced low-carbon biocrude for use by refineries and RNG for pipeline injection.
- Achieved temperatures in excess of 300°C.

TOTAL PROJECT COST	$2,503,456
SoCalGas	$1,008,720
CEC	$1,494,736

Next Steps
Genifuel is now pursuing two larger waste-to-energy demonstrations at waste-water treatment plants Contra Costa County, CA. and Vancouver, Canada.

Benefits:

SPOTLIGHT

Clean Transportation

Nation's first low-NOx medium-duty engine compliant with HD OBD requirements

New natural gas engine complies with heavy-duty on-board diagnostics requirements to reduce NOx and GHG emissions

Project Team
University of California, Riverside

Cummins Westport, Inc.

California Energy Commission

The RD&D Program supported the design, development, and demonstration of the first HD OBD-compliant, low-NOx natural gas engine for medium-duty (Class 5 to 7), commercial transportation applications.

Results:

- Engine maintained low emissions over range of realistic duty cycles.
- Reduced NOx emissions by >50% from federal standard for HD on-road vehicles.
- Engine is now commercially available

Next Steps:
HD-OBD technology will be integrated into current and future medium- and heavy-duty CNG engines.

TOTAL PROJECT COST:	$2,651,018
SoCalGas:	$134,375
CEC:	$1,000,000
Cummins Westport:	$1,516,643

Benefits:

SPOTLIGHT

Clean Generation

Project Team
University of California, Irvine

Microsoft

Cleaner, more reliable power for data centers

SoCalGas, UC Irvine, and Microsoft team up to integrate fuel cells for low emissions, reliable electricity at power-thirsty data centers.

In 2019, the SoCalGas RD&D Program, UC Irvine, and Microsoft joined forces to develop a greater understanding of how fuel cells could provide power to data centers and other critical infrastructure with sufficient reliability and resiliency.

Goals:

- Characterize typical power, energy, and demand dynamics for data centers.
- Integrate data into existing reliability models.
- Develop techno-economic analyses of real-world use-cases to determine market potential.

Next Steps:
UCI is pursuing $6M in DOE H2@Scale grant funding demonstrate integration of fuel cells with renewable hydrogen for reliable zero-emissions power at data centers

TOTAL PROJECT COST:	**$540,000**
SoCalGas:	$190,000
Microsoft:	$350,000

Benefits:

SPOTLIGHT

Customer End-Use Applications

Project Team
Gas Technology Institute

Utilization Technology Development

Wilson Engineering

California Energy Commission

Reducing food processing GHG emissions

SoCalGas and Gas Technology Institute develop breakthrough industrial drying technology

In 2019, SoCalGas collaborated with the Gas Technology Institute, Utilization Technology Development, Wilson Engineering, and the California Energy Commission to field-demonstrate a new high-efficiency drying technology.

Results:

- Reduced natural gas consumption by 65%.
- Lower electricity utilization by 40%.
- Recover substantial quantities of process water.

Next Steps:
SoCalGas RD&D is identifying follow-on demonstration sites and coordinating with GTI to adapt to other applications, particularly textile manufacturing

TOTAL PROJECT COST	$3,240,000
SoCalGas:	$400,000
CEC:	$2,600,000
UTD:	$160,000
Wilson Engineering:	$80,000

Benefits:

SPOTLIGHT

Gas Operations

Project Team
Pipeline Research Council International

Interstate Natural Gas Association of America

INGAA Foundation

American Petroleum Institute

Team develops comprehensive dataset and assesses dispersion model performance

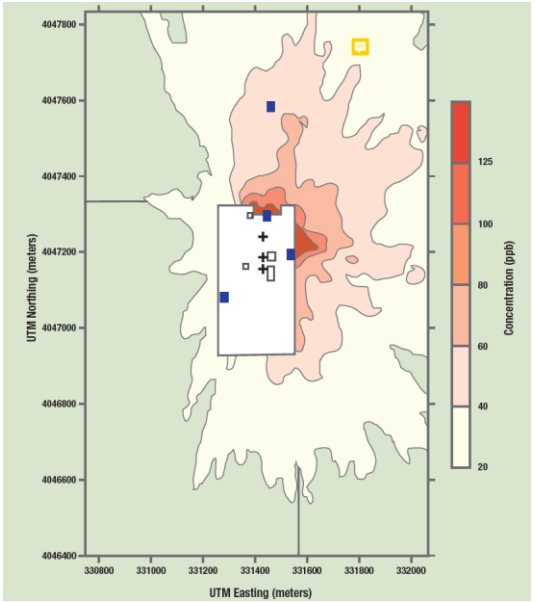
Industry collaboration builds robust dataset to gauge accuracy of exhaust plume air dispersion modeling tool

PRCI, in collaboration with SoCalGas and industry trade associations, evaluated the performance of AERMOD to better understand model bias or inaccuracies. Work with EPA continues to review analyses and develop a path to improve the model discrepancies identified.

Results:

- Defined alternatives to simulations assuming continuous emissions.
- Identified where AERMOD overpredicts NO2 formation in plume.

Next Steps:
The team will write a paper with alternatives for sources that do not operate continuously, improve Downwash models and participate in modeling workshop, and develop a path with EPA to modify models.



TOTAL PROJECT COST	**$3,172,000**
PRCI:	$2,003,000
SoCalGas:	$354,000
Others:	$815,0000

Benefits:

2019 Annual Report

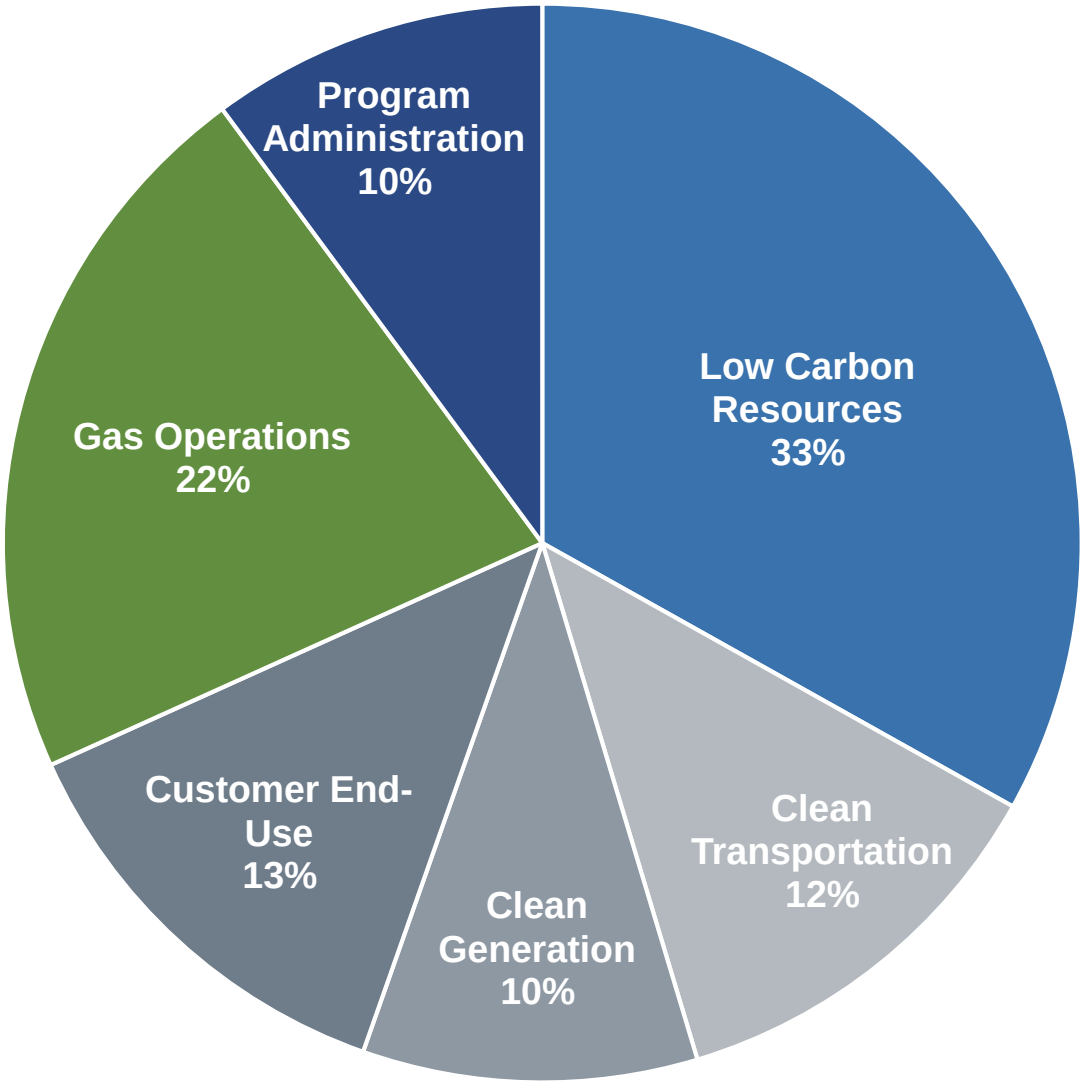
For more detailed information,

see the 2019 Annual Report.

III. Status and Changes for 2020

Planned 2020 Funding Allocation

$15,820,900 in planned funding



Important New Projects in 2020

- **Low Carbon Resources:**
  - HyET Hydrogen -- Electrochemical Hydrogen Compression and Purification
- **Gas Operations**:
  - Subsurface Multi-Utility Asset Location Detection (PHMSA/OTD 5.20.a)
- **Clean Transportation:**
  - UC Riverside Hydrogen Blended CNG Engine Emissions and Durability Test
- **Clean Generation:**
  - Lawrence Berkeley National Lab Metal-Supported Solid Oxide Fuel Cell Development
- **Customer End-Use Applications:**
  - GTI Residential Gas Heat Pump Water Heater Large-scale North America Field Demonstration

COVID-19 Update

COVID-19 continues to have an impact on several RD&D sponsored projects and collaborations.

- Funding for delayed projects will be retained, with flexibility to shift it to next year.
- The RD&D team is working with project managers and collaborators to identify areas where COVID-19 impacted project schedules need to be adjusted to continue work.
- Unprecedented events such as COVID-19 can offer opportunities to conduct new research to improve system safety, reliability, etc.

Sub-Program Modifications: Evergreen Names

The sub-program structure was changed in 2020 to achieve the following outcomes going forward:

- Establish broad enough sub-programs to encapsulate potential new research areas
- Create stable sub-program areas to make comparison and analysis easier from year to year
- Allow enough flexibility within sub-programs that future additions will not require sub-program name changes or additions.

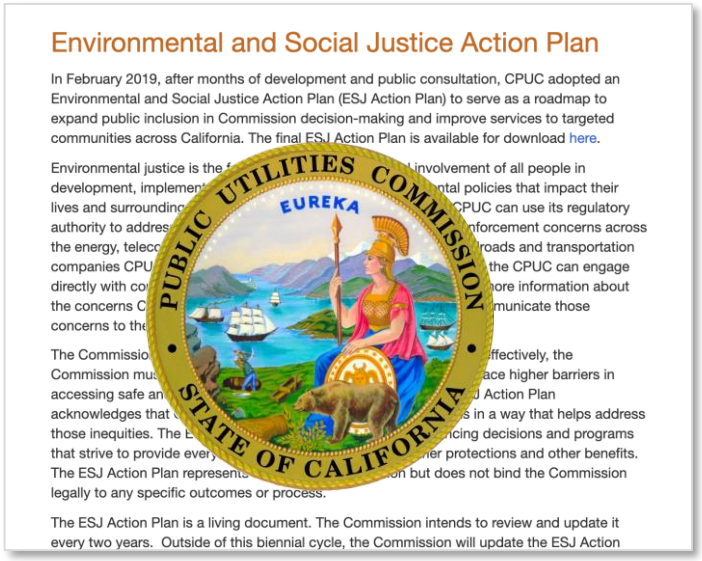
Modifications to Sub-Program Categories

Program	Previous Sub-Programs	New Sub-Programs
Low Carbon Resources	Biomass Processing & Conversion Power-to-Gas (P2G) Artificial Photosynthesis Carbon Capture & Use Hydrogen Production from Methane	Renewable Gas Production Low Carbon Gas Conversion Low GHG Chemical Processes
Gas Operations	Environmental & Safety Operations Technology System Design and Material System Inspection & Monitoring	Environmental & Safety Operations Technology System Design and Material System Inspection & Monitoring
Clean Transportation	Compression & Refueling Fuel Systems & Storage Near Zero Emissions Engines Compressed NG & Hybrid Vehicles Off Road Applications	On-Road Off-Road Refueling Stations Onboard Storage
Clean Generation	DG-CHP-MicroCHP Engines & Turbines Fuel Cells Waste Heat Recovery	Integration and Controls Distributed Generation
Customer End-Use	Zero Net Energy for Residential Appliance & IAQ Commercial Cooking & Food Service Solar Thermal Heating & Cooling Boilers & Process Heating	Commercial Food Service Residential Applications Commercial Applications Industrial Process Heat Advanced Innovation

Some specific areas we would like feedback

- Do the new Sub-Program names accurately describe the goal and purpose of each sub-program, while also providing flexibility to add new technologies in the future?

Equity and Inclusion



Environmental and Social Justice Action Plan

In February 2019, after months of development and public consultation, CPUC adopted an Environmental and Social Justice Action Plan (ESJ Action Plan) to serve as a roadmap to expand public inclusion in Commission decision-making and improve services to targeted communities across California. The final ESJ Action Plan is available for download here.

Environmental justice is the f involvement of all people in development, implement ntal policies that impact their lives and surroundinc CPUC can use its regulatory authority to addres nforcement concerns across the energy, telecc roads and transportation companies CPU the CPUC can engage directly with co ore information about the concerns C municate those concerns to the

The Commissio ffectively, the Commission mu ace higher barriers in accessing safe an Action Plan acknowledges that s in a way that helps address those inequities. The E icing decisions and programs that strive to provide ever er protections and other benefits. The ESJ Action Plan represent on but does not bind the Commission legally to any specific outcomes or process.

The ESJ Action Plan is a living document. The Commission intends to review and update it every two years. Outside of this biennial cycle, the Commission will update the ESJ Action

https://www.cpuc.ca.gov/CPUCNewsDetail.aspx?id=6442461331

The CPUC adopted an Environmental and Social Justice (ESJ) Action Plan to serve as a roadmap to expand public inclusion in Commission decision-making and improve services to targeted communities across California.

- The SCG RD&D Program considers Equity and ESJ in its program today, and it is considering formalizing this approach as an official part of the project selection process.

Equity and Inclusion

Examples of projects benefiting Disadvantaged Communities (DACs)

Brawley, CA (SDSU Satellite Campus)

- Low-cost concentrated solar (Hyperlight Energy)
- Hydrothermal processing dairy waste-to-energy (Genifuel Corp)
- Solar thermal advanced reactor system (STARS Technology Corporation)

Kern County Hwy-99 corridor

- Carbon negative energy from biomass gasification with carbon capture and sequestration with Clean Energy Systems
- GTI biomass gasification FEED study

Tulare, CA

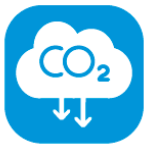
- Secured CEC Food Production Investment Program (FPIP) funding for a Hyperlight solar thermal project at the Saputo cheese plant

Mariposa, CA

- CEC funded Mariposa Biomass Projects utilizing Cortus Energy's biomass gasification technology

Corona, CA

- Demonstration of a new high-efficiency drying technology



Some specific areas we would like feedback

- How can the RD&D Program best address the needs of Disadvantaged Communities (DACs)?
- How best can the RD&D Program incorporate ESJ principles and benefits into their project selection process?

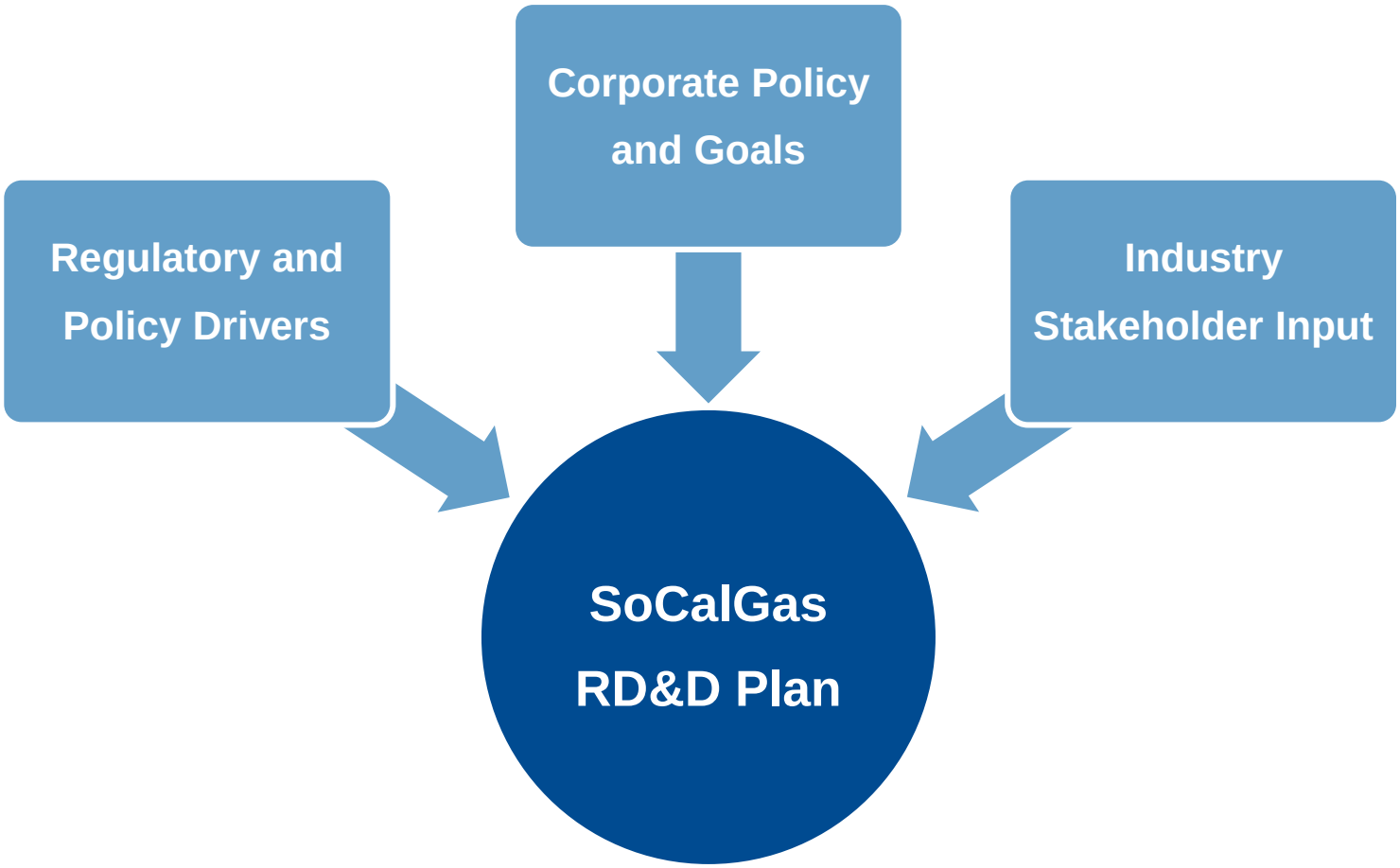
IV. RD&D Plan Development for Future RD&D

The RD&D Plan for 2021 and Beyond

To build the RD&D Plan, program staff consider multiple factors, including:

- Regulatory and policy drivers
- Corporate policy and goals
- Input from knowledgeable industry stakeholders
  - Universities, national labs, research consortia, public agencies, and businesses

The RD&D Plan for 2021 and Beyond



Regulatory Considerations

Category	Regulations & Policy Drivers
GHG Emissions	**AB32:** Reduce CO2 emissions 40% below 1990 levels by 2030 **SB 100:** Zero carbon electricity by 2045 **EO B-55-18:** Carbon-neutral California economy by 2045 **AB 3232:** Building decarbonization
Pipeline Safety	**CPUC General Order 112F:** Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems **DOT CFR 49 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
Methane Emissions	**SB 1383:** Reduce methane emissions from decomposition of organic wastes **CARB Oil and Gas Rule:** 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	**ARB Implementation Plan:** Low-NOx standard for trucks **AB 8:** Development of 100 hydrogen fueling stations in California **EO B-32-15:** 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
Equity	**CPUC ESJ Action Plan:** Increase investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health

Let's get there together!

Regulatory Considerations

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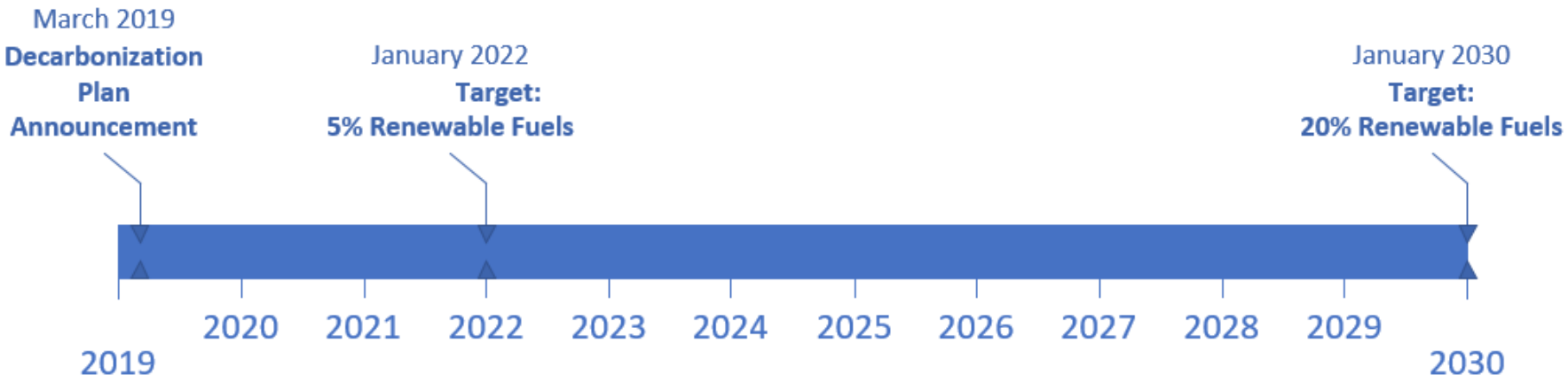
Equity	**CPUC ESJ Action Plan:** Increase investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health

Corporate Policy and Goals → Decarbonization

- SoCalGas's planned decarbonization targets for 2022 and 2030



Corporate Policy and Goals → Project Prioritization

SoCalGas 7 Critical Pathways inform RD&D planning efforts and will play a pivotal role in the state's transition to carbon neutrality by 2045.

	Natural Gas	GHG Emission Reduction	Renewable Natural Gas (RNG)	Distributed Energy (DE)	Hydrogen	Liquified Natural Gas (LNG)	Carbon Capture Utilization (CCU)
Description	▪ Needed for decades – provides affordability + complements renewables	▪ Continuous system improvement through targeted programs	▪ Partnership with agriculture waste stream sectors for RNG pipeline delivery	▪ Use fuel cells as wildfire mitigation measure + in transportation	▪ Hydrogen infrastructure ▪ Electrolysis ▪ Hydrogen blending into pipeline system	▪ Deployment of LNG facility at port of Los Angeles/Long Beach for transportation sector	▪ Capture waste carbon dioxide ▪ Deploy in carbon-utilizing industries such as manufacturing
Progress	▪ Continued safety enhancement investments	▪ Repaired multiple non-hazardous leaks since late 2018	▪ Goal to deliver 5% RNG by 2022 and 20% by 2030[2] ▪ Two fuel cell projects expected to be completed at SoCalGas facilities by mid-2020 ▪ Engineering and commercial progress underway; expect to launch demonstration hydrogen projects in 2020 + larger scale projects in 2022 – 2023			▪ Exploring opportunities	▪ Research, development + demonstration projects ▪ Exploring partnerships to commercialize technologies

Stakeholder Outreach

- SoCalGas reached out to the stakeholder community to elicit their opinions and get feedback on the RD&D Program
- Interviewed 20+ people at 10+ organizations

Stakeholder Feedback – Technology Development

Feedback Area	Key Take-Aways
Renewable and Low-Carbon Solutions	➢ Significant support for Hydrogen being a major part of the RD&D Plan ➢ Decarbonization requires multi-faceted development, including carbon neutral operations, biogas from landfills, NG system for H2, etc.
Resiliency Solutions	➢ Significant support for prioritizing resiliency and storage solutions, which is driving a shift in Clean Generation to look more at microgrids.
Air Pollution	➢ Emissions reduction was mentioned by a number of stakeholders, and it remains a key driver for stationary and transportation RD&D.
Safety & Health	➢ Hydrogen integration for appliances will be critical to H2 adoption and decarbonization. Must ensure equipment behaves safely with H2 blends. ➢ Driving many GasOps priorities, including impacts of subsidence

Stakeholder Feedback – Program Recommendations

Feedback Area	Key Take-Aways
Public Communication	➢ Increase amount of outreach information provided by SoCalGas to help inform stakeholders and the public at large regarding the RD&D Program ➢ Target national and international, as well as local, state, and regional stakeholders
Policy Considerations	➢ Consider how to support disadvantaged and / or low-income communities throughout the RD&D Program. ➢ Strong support for RD&D's increased emphasis on decarbonization
Other Input	➢ Technology transfer efforts are paramount, and should continue to be, or become an expanded element, of the SoCalGas RD&D Program ➢ SCG RD&D should leverage proximity to customers to speed deployment of new innovations.

The Result of These Inputs?

Regulatory and policy drivers, corporate policy and goals, and input from knowledgeable industry stakeholders has led the RD&D team to establish 3 Key RD&D Initiatives:

Hydrogen

GHG Emissions Reduction

Safety and Reliability

- Cross-cutting across Programs and Sub-Programs
- Provide the primary lens through which RD&D selects projects and prioritizes research

3 Key RD&D Initiatives

Hydrogen

- Zero-carbon fuel that's efficient and renewable
- Potential to form the basis for multi-faceted, multi-benefit scenarios
- Benefits to ratepayers through using SoCalGas existing pipeline network

GHG Emissions Reduction

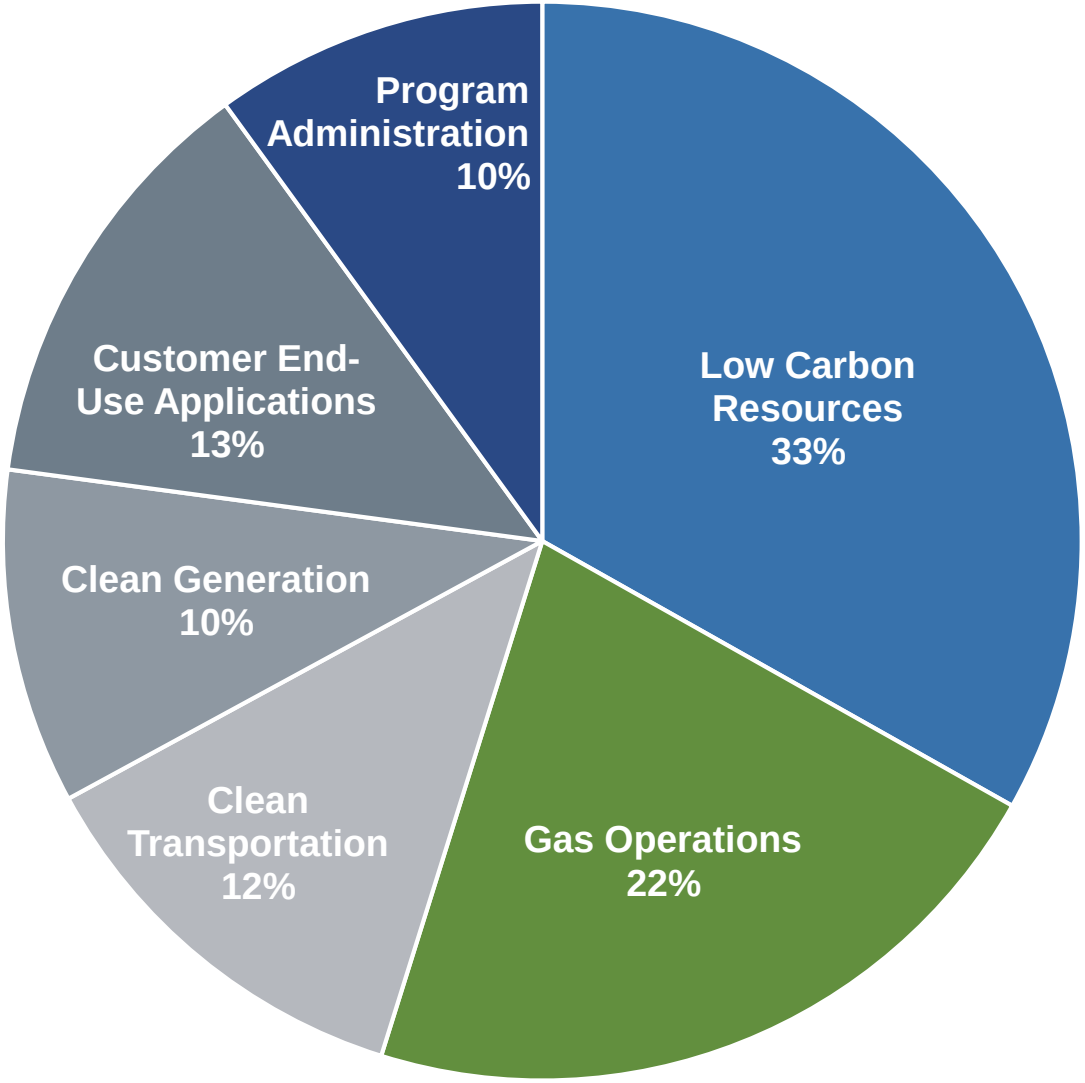
- Focus on meeting CA statutory goal and SoCalGas internal goals
- Target first-in-the-country gas utility advancements toward a decarbonized future
- Requires development, conveyance, and distribution of new renewable energy resources - namely renewable hydrogen and RNG

Safety and Reliability

- Critical across all operations and new development. Includes:
  - Safety specifications for alternative fuels—such as hydrogen
  - Operational and equipment safety and reliability
  - Geotechnical safety and resiliency
  - Support for the development of microgrids and other reliability-oriented technologies
  - Management of hazards associated with climate change

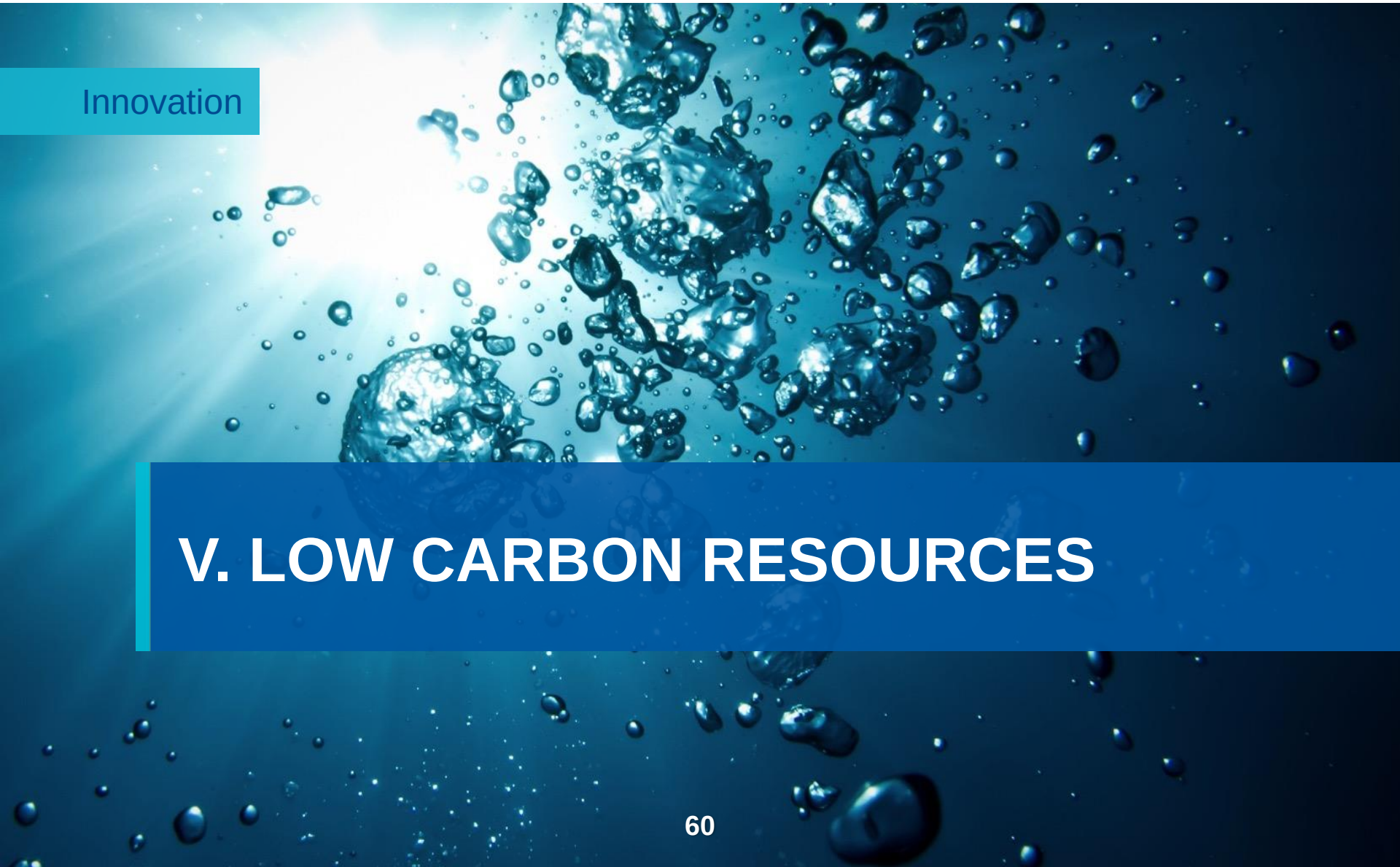
Proposed 2021 Funding Allocation

$16,180,000 in total **2021** funding



Some specific areas we would like feedback

- Do the new Sub-Program names accurately describe the goal and purpose of each sub-program, while also providing flexibility to add new technologies in the future?
- How can the RD&D Program best address the needs of Disadvantaged Communities (DACs)?
- Are there areas of research that we've overlooked?
- Are there other groups we should be speaking with?
- Are there other policy drivers that we should consider in our planning effort?



Innovation

V. LOW CARBON RESOURCES

Overview and Goals

The Low Carbon Resources RD&D Program develops technical solutions that can facilitate increasing and expanding the production of RNG and low-cost, low-carbon hydrogen to replace conventionally-sourced gas.

- Increasing the availability of RNG and hydrogen
- Facilitating the adoption of decarbonization solutions using cost-effective technologies
- Diversifying renewable gas production sources to encompass a broad variety of feedstocks and pathways

Example Projects

Methane Pyrolysis for Base-Grown Carbon Nanotubes and CO_2-Free Hydrogen

Total Project Cost	$1,719,000
Start → Finish	2/2/2018 - 12/31/2019
Participants	DOE, PNNL, W. Virginia University

The project's objective is to develop and demonstrate the economic viability of a new methane pyrolysis process which converts natural gas into carbon-dioxide free hydrogen and solid carbon by-products.

Opus 12 Methane Conversion System – Phase II

Total Project Cost	$1,025,000
Start → Finish	1/31/2019 - 1/31/2020
Participants	PG&E, JPL, SBIR, DOE

The project aims to develop and optimize an electrocatalytic methanation process can potentially be deployed at biomethane conditioning facilities to upgrade the high CO_2 content of biogas exiting biodigesters into renewable methane.

Example Projects

Low Carbon Resources

STARS Solar Microchannel Steam Methane Reformer Commercialization

Total Project Cost	$1,752,653
Start → Finish	11/2/2018 - 12/31/2020
Participants	DOE, PNNL

The project advances the development and manufacturing (3-D printing) of a new, high-efficiency, low-cost, distributed H_2 production technology using modular, combustion-free, solar-driven, steam-methane reforming technology.

Joint Center for Artificial Photosynthesis (JCAP) Industry Advisor Membership

Total Project Cost	$2,480,780
Start → Finish	1/12/2016 - 1/12/2021
Participants	DOE

Membership on the JCAP Industry Advisor Panel provides insights into sunlight-driven hydrogen production from water splitting, which has reached record conversion efficiency. In 2020, SCG will fund a commercial pilot project.

Program Structure

Low Carbon Resources

- Renewable Gas Production
- Low Carbon Hydrogen Production
- Low GHG Chemical Processes

Renewable Gas Production

- Focuses on the safe, reliable and cost-effective production of renewable and low-carbon gaseous fuels—specifically RNG and hydrogen.

Areas of Focus

- Biomass processing and conversion
- Hydrogen production from renewable sources
- Methanation

Contribute to Reductions in GHG Emissions

- Decarbonize the gas pipeline
- Reduce transportation fuel carbon intensity
- Recycle CO_2
- Improve air quality
- Increase energy affordability

Renewable Gas Production

Unique Elements

- **Methanation (Microbial and Catalytic) R&D**. Develop and scale methanogenesis processes using renewable electricity and biogenic CO_2.
- **Hydrogen Production via Direct Solar to Water Splitting.** Generate hydrogen via water splitting using high-efficiency solar capture technology.
- **Biomass Processing and Conversion.** Produce renewable methane from waste sources using emerging new gasification technologies

Low Carbon Hydrogen Production

Low Carbon Resources

- Focuses on the production of low carbon hydrogen using various methane feedstocks.

Areas of Focus

- Methane pyrolysis
- Advanced steam methane reforming technologies

- Low carbon / low cost hydrogen production
- Consider both RNG and Methane as feedstocks
- Achieve process efficiency improvements and cost reductions

Low Carbon Hydrogen Production

Low Carbon Resources

Unique Elements

- **Methane Pyrolysis.** SoCalGas is exploring 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.).
- **Low Cost/Low Carbon Distributed Hydrogen Production.** SoCalGas is working closely with JPL and PNNL on two steam methane reforming projects that have the potential to enhance the efficiency and compactness of the process, while greatly reducing its cost and carbon footprint.

Low GHG Chemical Processes

- Focuses on technologies that can help minimize reliance on natural gas combustion, as well as technologies for the capture and conversion of GHG emissions into valuable chemicals.

Areas of Focus

- Application of concentrated solar power technology (CSP) to industrial processes
- Carbon Capture and Utilization (CCU)
- Carbon Capture and Sequestration (CCS)

Of Note

CCU is being evaluated to manufacture concrete, solid carbon by-products, liquid chemicals, etc.

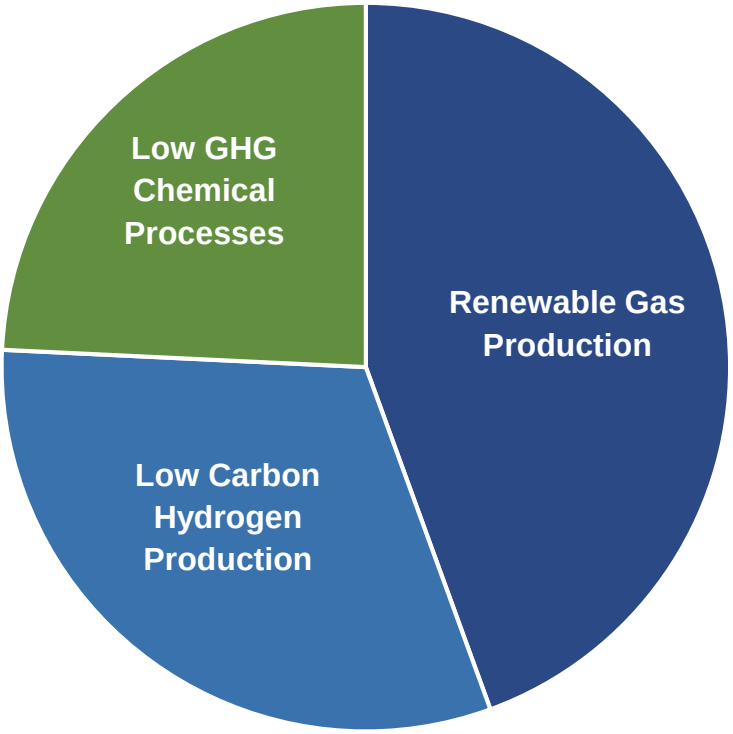
Low GHG Chemical Processes

Unique Elements

- **Carbon Capture and Use (CCU):** Challenging research program that explores technologies and processes related to carbon negative cycles, carbon capture sorbents for biogas upgrading, carbon conversion into valuable chemicals such a methanol, DME, concrete, etc.
- **Carbon Capture and Sequestration (CCS):** Investigating the use of saline aquifers in the San Joaquin Valley to sequestrate CO_2.
- **Concentrated Solar Power (CSP):** CSP technology can significantly lower a facility's carbon footprint by minimizing its reliance on NG combustion.

2021 Proposed Funding Allocation

Low Carbon Resources



Sub-Program	Allocation
Renewable Gas Production	44%
Low Carbon Hydrogen Production	31%
Low GHG Chemical Processes	24%
Total	**$5,365,857**

Some specific areas we would like feedback

- Do the Sub-Program names accurately describe the goal and purpose of each sub-program, while also providing flexibility to add new technologies in the future?
- Are there areas of research that we have overlooked?
- Is the funding allocated appropriately to further programs goals and initiatives?
- Are there other groups we should be speaking with?

Innovation

BREAK

Innovation

VI. CLEAN TRANSPORTATION

Overview and Goals

The Clean Transportation RD&D Program focuses on minimizing environmental impacts related to the transportation sector through the development of:

- Low-carbon fuels
- Zero- and near-zero emissions engines & vehicles
- Fueling infrastructure
- Advanced on-board storage technologies

Example Projects

Clean Transportation

SCAQMD In-Use Emission Study

Total Project Cost	$3,285,000
Start → Finish	11/1/2015 - 12/31/2020
Participants	SCAQMD, CEC, CARB

The purpose of this project is to conduct in-use emissions testing, fuel usage profile characterization, and an impact assessment of current technology and alternative fuels on fuel consumption and in-use emissions from heavy-duty vehicles.

GTI CNG Smart Station Demonstration

Total Project Cost	$1,500,000
Start → Finish	1/31/2019 - 12/31/2021
Participants	GTI, UTD, NREL, University of Texas at Austin

The goal of this project is to develop an advanced control algorithm to eliminate issues associated with underfilling and apply it in a smart compressed natural gas (CNG) station.

Example Projects

Clean Transportation

SCAQMD Ford 7.3 NZE Development

Total Project Cost	$4,379,747
Start → Finish	11/30/2019 - 12/31/2021
Participants	SCAQMD, Ford, Landi Renzo, Agility Fuel Systems, US Gain

The purpose of this project is to develop and commercialize a CNG NZE variant of the Ford 7.3L CNG engine for medium-duty trucks.

GTI ZANZEFF Hydrogen Fuel Cell Yard Truck Demonstration

Total Project Cost	$12,055,413
Start → Finish	1/1/2019 - 3/31/2021
Participants	CARB, BAE, REV Group, HTEC, ZEN, Ballard, Port of LA

The objective of this project is to develop and deploy a hydrogen fuel cell yard truck fleet at the Port of Los Angeles. This is a first of its kind project meant to demonstrate reliability, performance, durability, and affordability.

Program Structure

Clean Transportation

- On-Road
- Off-Road
- Refueling Stations
- Onboard Storage

On-Road

- Targets emissions reductions from medium- and heavy-duty on-road vehicles.

Areas of Focus

- Focus on on-road transportation technologies using Natural Gas, Renewable Natural Gas, and Hydrogen

Critical research area since Medium- and Heavy-Duty Trucks contribute to over 50% of total NOx emissions in the South Coast Air Basin.

Unique Elements

- **Focus on NOx *AND* GHG Emissions**. Most research programs focus on one or other, SoCalGas RD&D targets both simultaneously.
- **Local Collaboration** with SCAQMD and SJVAPCD cover two regions classified as "extreme" non-attainment areas for the NAAQS Ozone Requirements.
- **Customer Relationships**. SoCalGas works closely with local customers and fleets to develop new technologies that address their challenges while improving air quality and reducing emissions.

Off-Road

- 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.

Areas of Focus

- Focus on developing zero- and near-zero emission off-road transportation solutions using Natural Gas, Renewable Natural Gas, and Hydrogen

Critical research area since Off-road mobile sources contribute over 30% of total NOx emissions in the South Coast Air Basin.

Off-Road

Unique Elements

- **Focus on NOx *AND* GHG Emissions + Local Collaboration**. Like On-Road, Off-Road focuses on both NOx and GHG and fosters key local collaborations with SCAQMD and SJVAPCD.
- **Local Knowledge/National Impact:** Southern California has the 2 largest U.S. ports that handle 30% of all U.S. imports. Improvements here can benefit local air quality for communities and could represent significant GHG reductions for the U.S.

Refueling Stations

- Targets development, demonstration, and deployment of technologies and systems that support refueling for alternative fuels, including CNG, RNG, and hydrogen.

Areas of Focus

- The program seeks to both identify and manage concerns and issues arising from refueling of gaseous fuels—from storage to safety and standardization—while supporting the deployment of additional gaseous fuel refueling facilities

Refueling Stations

Unique Elements

- **Support for New Refueling Station Deployment:** Actively supports the deployment of hydrogen, RNG, and CNG based refueling stations across the Southern California region.
- **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.

Onboard Storage

- Targets the development, demonstration, and deployment of technologies and systems that improve onboard storage for gaseous transportation fuels.

Areas of Focus

- These 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.

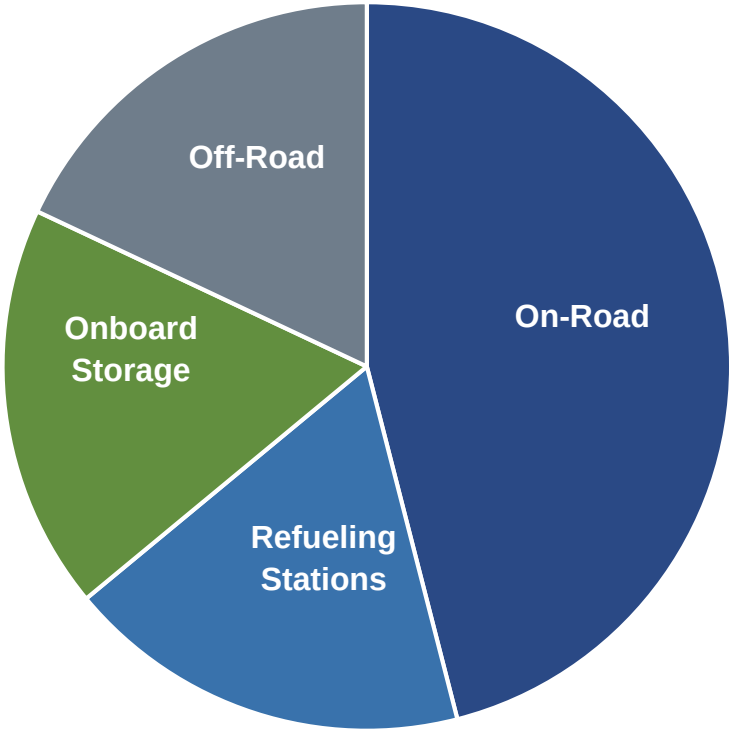
Onboard Storage

Unique Elements

- **Industry Collaboration**. Actively collaborate with CNG and hydrogen end-use customers and manufacturers to understand needs.
- **Safety & Standardization:** These critical components of commercialization of gaseous alternative fuel vehicles are often overlooked by other funding programs—where funding often targets demonstration but may overlook long term standardization.

2021 Proposed Funding Allocation

Clean Transportation



Sub-Program	Allocation
On-Road	46%
Off-Road	18%
Refueling Stations	18%
Onboard Storage	18%
Total	**$1,981,708**

Some specific areas we would like feedback

- Do the Sub-Program names accurately describe the goal and purpose of each sub-program, while also providing flexibility to add new technologies in the future?
- Are there areas of research that we have overlooked?
- Is the funding allocated appropriately to further programs goals and initiatives?
- Are there other groups we should be speaking with?

Innovation

VII. CLEAN GENERATION

Overview and Goals

Clean Generation

The Clean Generation RD&D Program focuses on supporting the development and demonstration of high-efficiency, low-emissions distributed generation systems for the commercial, industrial, and residential market segments in order to:

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

Example Projects

Blue Frontier Fuel Cell Powered HVAC Development

Total Project Cost	$540,527
Start → Finish	11/1/2019 - 3/31/2021
Participants	Blue Frontier

This project investigates the integration of a fuel cell with Blue Frontier's Enhanced Liquid Desiccant Energy Storage Air Conditioning. This technology recovers and stores the waste heat from the fuel cell in order to provide on demand cooling.

UCI Integrated SOFC, Solar, and Storage System in Zero Net Energy Residential Nanogrid

Total Project Cost	$325,000
Start → Finish	10/1/2019 - 9/30/2021
Participants	N/A

The purpose of this project is to design and analyze a residential nano-grid that integrates solid oxide fuel cells, CHP, PV solar, and energy storage and dynamically operate the system in order to meet typical residential heating and power demands.

Example Projects

UCI Fuel Flexible Microturbine Generator Development

Total Project Cost	$100,000
Start → Finish	5/1/2019 - 9/30/2020
Participants	UC-Irvine

This project demonstrates low-emissions operation of a hydrogen-tolerant microturbine-based CHP system. The project modifies a C-60 microturbine to accept hydrogen-blended fuel.

UTD CHP System with Integrated Particle Thermal Energy Storage

Total Project Cost	$791,677
Start → Finish	6/16/2017 - 1/31/2019
Participants	DOE, UTD, Thermal Transfer Corporation, PSRI

The objective of this project is to prove the ability of capturing and storing at least 50% of the thermal energy available in micro-turbine exhaust gas for on-demand reuse.

Program Structure

Clean Generation

- Integration & Controls
- Distributed Generation

Integration and Controls

Clean Generation

- Develop and enhance technologies and control systems that integrate distributed generation resources and thermal loads.

Areas of Focus

- Fuel cell supported microgrids
- Advanced electric and thermal load management of CHP systems

Focuses on enabling low emissions distributed generation and storage technologies to provide **energy resilience and affordability** to customers.

Integration and Controls

Clean Generation

Unique Elements

- **Hydrogen Integration.** Develop microgrid standards, safety elements, and integration procedures for hydrogen and other gaseous fuels.
- **Customer Needs**. Microgrids are custom implementations, requiring a strong understanding of customer needs – SoCalGas is able to provide these customer relationships.

Distributed Generation

Clean Generation

- Develop and enhance distributed generation technologies.

Areas of Focus

- Clean alternatives to diesel backup generators
- Modifying existing CHP systems to safely operate on hydrogen
- Utilizing waste heat to generate power

Microgrids and the increasing availability of RNG and hydrogen offer new opportunities for the deployment of low emission and renewable fueled distributed generation technologies

Distributed Generation

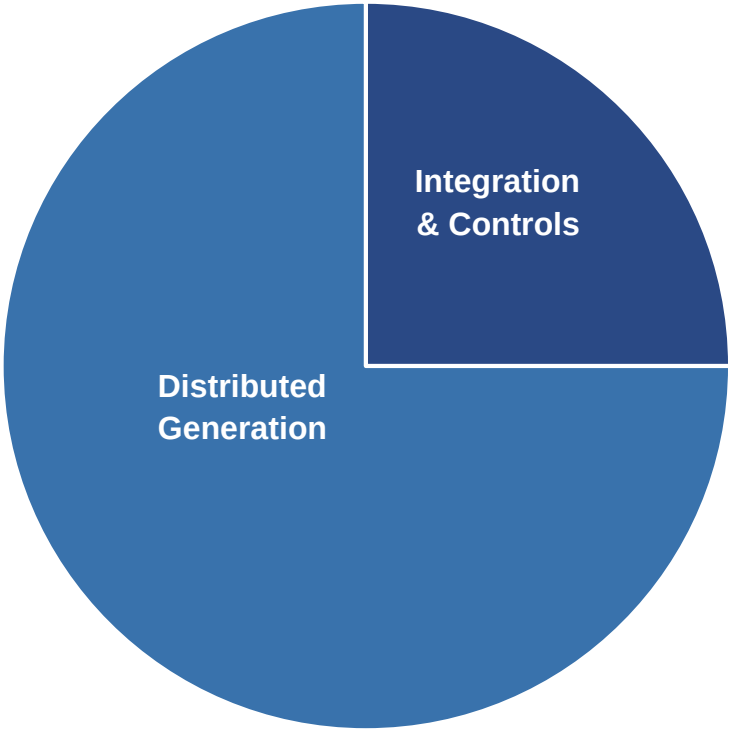
Clean Generation

Unique Elements

- **Low Emissions Backup Generation**. As backup generation becomes increasingly important in California, low emissions backup generation will help to ensure public health even during emergency operations.
- **Hydrogen Integration**. Develop DG standards, safety elements, and integration procedures for hydrogen and other gaseous fuels.
- **Local Knowledge**. SoCalGas has the only 2 extreme non-attainment zones in the US in its service territory, requiring generating solutions that meet specific air quality requirements.

2021 Proposed Funding Allocation

Clean Generation



Sub-Program	Allocation
Integration & Controls	25%
Distributed Generation	75%
Total	**$1,935,289**

Some specific areas we would like feedback

- Do the Sub-Program names accurately describe the goal and purpose of each sub-program, while also providing flexibility to add new technologies in the future?
- Are there areas of research that we have overlooked?
- Is the funding allocated appropriately to further programs goals and initiatives?
- Are there other groups we should be speaking with?

Innovation

LUNCH

Innovation

VIII. CUSTOMER END-USE APPLICATIONS

Overview and Goals

Customer End-Use

The Customer End-Use Applications RD&D Program focuses on developing end-use technologies that:

- Cost-effectively improve the efficiency and reduce the environmental impacts of gas end-use applications
- Support the development/deployment of technologies that meet air emissions and energy efficiency goals
- Increase safety and performance while reducing cost

Example Projects

Customer End-Use

EAC Testing of Hydrogen/NG Blend Impact on Appliances – Phase 2

Total Project Cost	$24,000
Start → Finish	10/26/2018 - 12/31/2019
Participants	NYSEARCH

The project develops a tool that generates graphical depictions of performance characteristics for appliances with different gas supply composition data with phase 2 incorporating hydrogen and biogas data.

GTI Gas Heat Pump Water Heating and Space Cooling in Restaurants Demo

Total Project Cost	$1,090,294
Start → Finish	4/17/2019 - 12/31/2020
Participants	CEC, GTI

In this project, Gas Technology Institute (GTI) is conducting a field demonstration of an advanced pre-commercial gas heat pump (GHP) for commercial hot water and space cooling as applied to two restaurants.

Example Projects

Customer End-Use

UTD High Efficiency Thermo Vacuum Commercial Clothes Dryer – Phase 2

Total Project Cost	$185,000
Start → Finish	6/1/2017 - 6/30/2019
Participants	UTD, Wilson Engineering Technology, ORNL

The objective for this project is to develop and test a prototype high-efficiency, natural gas-fired thermo-vacuum clothes dryer (TVCD) and demonstrate the technical and economic benefits over the state-of-the-art dryer.

GTI SCAQMD HE/Low-NOx EcoZone Burner Kroger Demonstration

Total Project Cost	$2,052,000
Start → Finish	11/1/2019 - 1/31/2023
Participants	SCAQMD, Kroger, SoCalGas EE

This project will demonstrate a high-efficiency low-NOx ribbon burner at a commercial baking facility located within a environmental justice area. The goal is to demonstrate at least 25% NOx emission reduction and at least 10% energy savings.

Program Structure

Customer End-Use

Customer End-Use Applications

- Commercial Food Service
- Residential Appliances
- Commercial Applications
- Industrial Process Heat
- Advanced Innovation

Commercial Food Service

Customer End-Use

- Develop and enhance technologies and advancements related to commercial food service.

Areas of Focus

- Includes restaurants, catering services, and institutional kitchens that primarily rely on fuel supplied by SoCalGas for cooking and water heating

RD&D therefore focuses primarily on these end-uses, to improve energy efficiency, increase safety, and reduce emissions.

Commercial Food Service

Customer End-Use

Unique Elements

- **Emissions Characterization.** Measure emission from CFS equipment, identify opportunities for emissions reduction, and prioritize applications for RD&D projects
- **Advanced Next Generation Burners.** Develop and commercialize advanced burners that reduce pollutant emissions, minimize GHG emissions, and provide safer, more effective heating.

Residential Applications

Customer End-Use

- Develop and enhance technologies and advancements related to gas-consuming appliances in residences.

Areas of Focus

- Relevant appliances include furnaces, hot water heaters, stoves, ovens, and dryers.

Cost-effective decarbonization through extreme energy efficiency increases coupled with integration of low carbon fuels like hydrogen.

Residential Applications

Customer End-Use

Unique Elements

- **Extreme Energy Efficiency Improvements**: Identify, develop, and commercialize technologies providing extreme efficiency improvement.
  - *For example, gas heat pumps with COP > 1.2*
- **Hydrogen and RNG Integration:** Safe, efficient, and effective technologies that will enable the use of hydrogen and RNG for residential appliances.
- **Indoor Air Quality:** Identify, characterize, and address emissions sources including building materials, synthetic fabrics, and insulations.

Commercial Applications

Customer End-Use

- Develop and enhance technologies and advancements related to gas consumption and end-uses in the commercial sector.

Areas of Focus

- Relevant applications include commercial HVAC, hot water service, and commercial laundry.

Cost-effective decarbonization through extreme energy efficiency increases coupled with integration of low carbon fuels like hydrogen.

Commercial Applications

Customer End-Use

Unique Elements

- **Commercial Building Equipment:** Uniquely positioned to make an impact, with close contact to a wide array of commercial end-users.
- **System Integration:** The scale of commercial systems allows for greater integration of applications.
  - *For example: Water heating and space conditioning can be cost-effectively coupled to reduce energy consumption for both.*

Industrial Process Heat

Customer End-Use

- Develop advanced heating technologies and systems for use in the industrial sector.

Areas of Focus

- Relevant applications include food processing, textile drying, chemical processing, and other process heat needs.

The industrial process heat end-use sector represents some of the largest users of gaseous fuels and the most difficult applications to decarbonize.

Industrial Process Heat

Customer End-Use

Unique Elements

- **Food Processing:** ~$200 billion of annual economic activity in California. Cost-effective decarbonization may best be achieved through increased efficiency coupled with renewable fuels integration.
- **Other Process Heating**: Chemical refining, textile production, and industrial cleaning are difficult to decarbonize. Heat pump and other highly efficient technologies developed for the residential and commercial sector could be scaled to address these needs

Advanced Innovation

Customer End-Use

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

Hardware Areas of Focus		Software Areas of Focus
• Building envelope improvements • Phase change materials • Heat recovery • Thermal storage • Others	+	• Smart appliances • Smart buildings • Internet of things (IoT) • Artificial intelligence (AI) • Others

Advanced Innovation

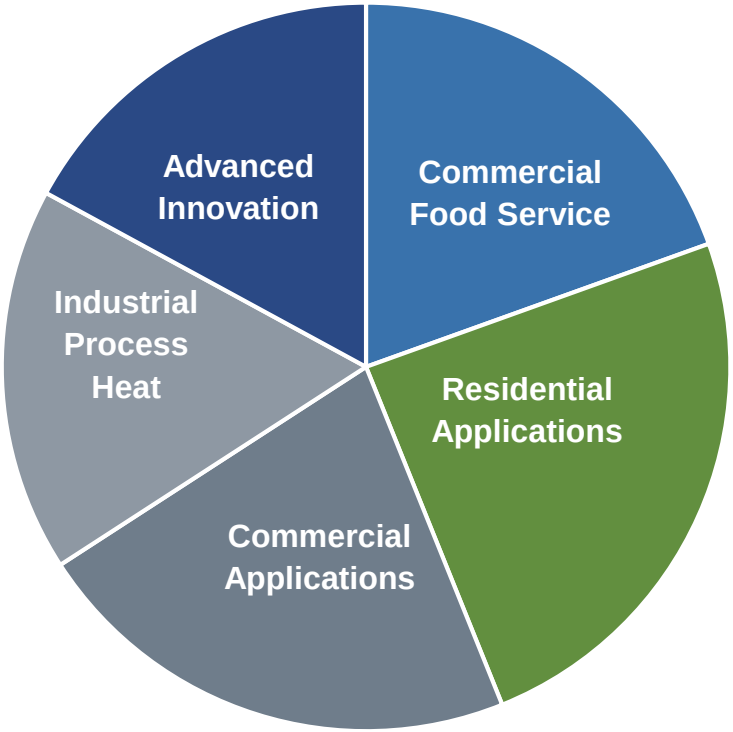
Customer End-Use

Unique Elements

- **Advanced Hardware Technologies:** Energy efficiency remains the least expensive GHG mitigation pathway.
  - *Exploring phase change compounds embedded in building materials and advanced ductwork sealing products*
- **Exploring Smart Technologies:** Smart Gas Meters transmit usage data through a mesh network that is extremely reliable.
  - *Additional research will investigate how to leverage the meter network and other communications systems to securely connect appliances to smart homes and thermostats for real-time optimization.*

2021 Proposed Funding Allocation

Customer End-Use



Sub-Program	Allocation
Commercial Food Service	20%
Residential Applications	24%
Commercial Applications	22%
Industrial Process Heat	17%
Advanced Innovation	17%
Total	**$2,083,334**

Some specific areas we would like feedback

- Do the Sub-Program names accurately describe the goal and purpose of each sub-program, while also providing flexibility to add new technologies in the future?
- Are there areas of research that we have overlooked?
- Is the funding allocated appropriately to further programs goals and initiatives?
- Are there other groups we should be speaking with?

Innovation

IX. GAS OPERATIONS

Overview and Goals

Gas Operations

The Gas Operations RD&D Program works across the SoCalGas distribution, transmission, and storage system, leveraging new technologies and advances on existing systems and processes to:

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

Example Projects

Gas Operations

InSAR Monitoring of Pipeline Geohazards in Vegetated and Very Large Non-Vegetated Areas

Total Project Cost	$253,228
Start → Finish	1/1/2019 - 3/20/2020
Participants	PRCI Members

The project demonstrates the recent advances in InSAR (radar satellite imagery) and will develop guidelines for how InSAR can be utilized to monitor pipeline networks for geohazards over large geographic areas.

Automation of the Explorer Series of Robotic Platforms Phase I, II, II-a

Total Project Cost	$4,212,620
Start → Finish	2/28/2017 - 12/31/2020
Participants	NYSEARCH, Invodane

The project will reduce the operational complexity associated with deployment of the Explorer for internal inspection of pipelines while increasing its overall inspection capability by automating its operation/control.

Example Projects

Gas Operations

Subsurface Multi-Utility Asset Location Detection

Total Project Cost	$2,095,383
Start → Finish	1/1/2020 - 12/31/2021
Participants	OTD, DOT/PHMSA, Others

The project's goal is to demonstrate an on-pipe electronic marking system using radio frequency markers (RFID) along with a high accuracy GPS system to improve the accuracy of locating PE pipe.

Fault Displacement Hazard Initiative (UCLA)

Total Project Cost	$2,415,000
Start → Finish	11/20/2018 - 12/31/2020
Participants	UCLA, PG&E, Caltrans, Others

The project will develop a robust and reliable model, that will accommodate both vintage and new datasets, for forecasting the distribution and magnitude of displacements from surface rupture in order to support risk analysis.

Program Structure

Gas Operations

Gas Operations

- Environmental & Safety
- Operations Technology
- System Design & Materials
- System Inspection & Monitoring

Environmental & Safety

Gas Operations

- Targets improved management of operations and facilities to support environmental compliance and safety targets, including current and anticipated future requirements.

Environmental		Safety
Working in Sensitive Habitats & Congested Operating Environments, Site Restoration, Combustion Emissions, Criteria Pollutants, Vented and Fugitive natural gas emissions	+	Pipeline safety issues related to customer, public, and worker safety; including pipeline locate-and-mark, damage prevention, and automatic shut-off technologies

Environmental & Safety

Gas Operations

Unique Elements

- Including Environmental & Safety with the RD&D program, alongside other research projects, is a unique advantage to SoCalGas.
- E&S accelerates deployment of new technologies by screening and testing them – and adapting them as necessary – to meet SoCalGas environmental safety requirements and regulations.

Operations Technology

Gas Operations

- Seeks to advance and develop techniques for pipeline construction, operation, maintenance, rehabilitation, and testing of gas pipelines and systems that facilitate the continued safe and reliable service.

New Procedures and Devices

- Instruments
- Measurements
- Methodologies
- Related activities

Critically – these are technologies that SoCalGas employees use every day to keep the SoCalGas pipeline system online, safe, and operating optimally.

Operations Technology

Gas Operations

Unique Elements

- Unlike state and federal RD&D programs, this sub-program directly targets operational needs of SoCalGas as a utility.
- *Early adoption of the most advanced pipeline operations technologies*
- *Supports safety, resiliency, optimized operation, and regulatory compliance*.

System Design & Materials

Gas Operations

- Engineering, development, and design of the SoCalGas natural gas system and associated materials – research needs continue to evolve, driven by pipeline safety, new materials, and new system solutions.

A Transition to RNG & Hydrogen

These gases may affect legacy and new pipeline systems and their materials, requiring research

High Strength Pipeline Materials

New materials require modeling, infrastructure evaluations, and other research to help minimize incidents

Physical Disruption RD&D

Research informs planning for earthquakes, subsidence, and other physical disruptions to the system

System Design & Materials

Gas Operations

Unique Elements – System Variables

Seismic Threats and Geohazards

Address unique materials concerns for Southern California, exploring new and existing materials and systems.

Machinery Threats

Address unique Southern California threats to underground equipment from heavy loads, mechanical threats, excavation disturbance, etc.

Legacy Infrastructure

Address ongoing maintenance, improvement, and interconnection with contemporary materials and systems impacting the SoCalGas system.

System Inspection & Monitoring

Gas Operations

- Leverage sensors and data science (“big data”) to monitor, analyze, and inspect SoCalGas systems to prevent and/or more rapidly respond to system issues.

Technology Solutions to help manage, maintain, and monitor the condition of pipelines

- Artificial Intelligence
- Machine Learning
- Internet of Things (IoT)
- Related data and analysis projects

These efforts help SoCalGas respond proactively to events and changes in conditions.

System Inspection & Monitoring

Gas Operations

Unique Elements

Subsidence

Managing subsidence, particularly in the Central Valley, is a considerable challenge with respect to SoCalGas pipelines. Unique RD&D is required to address.

Environmental Challenges

Climate change, sea level rise, increased incidence of wildfires, mudslides, and other environmental challenges all must be weathered by SoCalGas's system and requires area-specific RD&D.

Big Data

This sub-program uniquely leverages extensive data available to SoCalGas to better understand environmental and geohazard challenges, as well as general operations and safety challenges.

2021 Proposed Funding Allocation

Gas Operations

Sub-Program	Allocation
Environmental & Safety	24%
Operations Technology	6%
System Design and Material	38%
System Inspection & Monitoring	33%
Total	**$3,505,083**

Some specific areas we would like feedback

- Do the Sub-Program names accurately describe the goal and purpose of each sub-program, while also providing flexibility to add new technologies in the future?
- Are there areas of research that we have overlooked?
- Is the funding allocated appropriately to further programs goals and initiatives?
- Are there other groups we should be speaking with?

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WRAP-UP

Presentation Objectives and Structure

Provide results from 2019

I. RD&D Overview and Structure

II. 2019 in Review

Give an update on 2020

III. Status and Changes for 2020

Seek input for 2021

IV. RD&D Plan Development

V. Low Carbon Resources

VI. Clean Transportation

VII. Clean Generation

VIII. Customer End-Use

IX. Gas Operations

Agenda

	Start Time	Duration (mins) Total *(presentation/Q&A)*	Topic
Section 1 90 mins	9:30am	60 mins *(45 pres. + 15 Q&A)*	Overview, Status, & Updates (I. → IV.)
	10:30am	30 mins *(15 pres. + 15 Q&A)*	Low Carbon Resources (V.)
	11:00am	**15 mins**	**BREAK**
Section 2 60 mins	11:15am	30 mins *(15 pres. + 15 Q&A)*	Clean Transportation (VI.)
	11:45am	30 mins *(15 pres. + 15 Q&A)*	Clean Generation (VII.)
	12:15pm	**45 mins**	**LUNCH**
Section 3 95 mins	1:00pm	30 mins *(15 pres. + 15 Q&A)*	Customer End-Use Applications (VIII.)
	1:30pm	30 mins *(15 pres. + 15 Q&A)*	Gas Operations (IX.)
	2:00pm	35 mins *(5 pres. + 30 Q&A)*	Wrap-up + Q&A
	2:35pm		**ADJOURN**

Meeting Notes

- Remaining workshop time will be used for addressing questions and comments.
- Please submit questions on in the GoToMeeting questions box. Due to time constraints, questions and comments will be limited to 1 minute.
- Participants will have until **Friday, May 1st** to submit written questions and comments to rddinfo@socalgas.com

Innovation

QUESTIONS AND COMMENTS

Areas we would like feedback

- Are there other organizations engaged in gas research and development we should be speaking with?
- Are there areas of research or new technologies that we've overlooked?
- Are there any new legislative or policy priorities we should consider in our planning process?
- In what ways should SoCalGas RD&D conduct additional outreach and education with organizations engaged in gas research and development and/or the general public?

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APPENDIX SLIDES

Acronyms & Abbreviations

AB	Assembly Bill
AERMOD	American Meteorological Society/Environmental Protection Agency
API	American Petroleum Institute
AR	Augmented Reality
ARPA-E	US Department of Energy's Advanced Research Projects Agency-Energy
BAE	British Aerospace Systems
BWAT	Blue Water Area
CalGEM	Geologic Energy Management Division
CARB	California Air Resources Board
CEC	California Energy Commission
CFR	Code of Federal Regulations
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CPUC	California Public Utilities Commission
CRADA	Cooperative Research and Development Agreement
CSP	Concentrated Solar Power
CWI	Cummins Westport Inc.
DAC	Disadvantaged Communities
DG	Distributed Generation
DG-CHP	Distributed Generation/Combined Heat-and-Power Systems
DOE	US Department of Energy
DOGGR	Division of Oil, Gas, and Geothermal Resources
DOT	US Department of Technology
E&S	Environmental & Safety
EAC	Engineering Analysis Center
EC	Eddy Current, Electric Charge
EO	Executive Order
EPA	US Environmental Protection Agency
g/bhp-hr	Grams per brake horsepower-hour
GHG	Greenhouse Gas
GHP	Gas Heat Pump
GRC	General Rate Case
GTI	Gas Technology Institute
H2	Hydrogen
HD OBD	Heavy-Duty On-Board Diagnostics
HTEC	Hydrogen Technology and Energy Corporation
HTP	Hydrothermal Processing
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
INGAA	Interstate Natural Gas Association of America Foundation
JCAP	Joint Center for Artificial Photosynthesis
JPL	Jet Propulsion Laboratory
kW	Kilowatt
LCFS	Low Carbon Fuel Standard
LLNL	Lawrence Livermore National Laboratory
mins	Minutes
MTG	Microturbine Generator
NFP	Not For Profit
NG	Natural Gas
NREL	National Renewable Energy Laboratory
NYSEARCH	Northeast Gas Association
NZE	Near-Zero Emission Engine
ORNL	Oak Ridge National Laboratory
P2G	Power-to-Gas
PEMFC	Proton Exchange Membrane Fuel Cell
PG&E	Pacific Gas and Electric
PHMSA	Pipeline and Hazardous Materials Safety Administration
PNNL	Pacific Northwest National Laboratory
PRCI	Pipeline Research Council International
PSRI	Particulate Solid Research Inc.
PVC	Polyvinyl Chloride
Q&A	Question & Answer
RD&D	Research, Development, and Demonstration
REV	REV Group
RNG	Renewable Natural Gas
SB	Senate Bill
SBIR	Small Business Innovation Research
SCAQMD	South Coast Air Quality Management District
SJVAPCD	San Joaquin Valley Pollution Control District
SOFC	Solid Oxide Fuel Cell
STARS	Solar Thermochemical Advanced Reactor System
TVD	Thermal-Vacuum Drying
UCI	University of California, Irvine
UCR	University of California, Riverside
UTD	Utilization Technology Development
ZANZEFF	Zero and Near Zero-Emission Freight Facilities
ZNE	Zero Net Energy

Selection of 2019 Funding Recipients

Aeris Technologies Inc
Agileone
Alexanders Mobility Services
Alliance for Sustainable Energy LLC
Avineon Inc
Barnett Technical Services LLC
Battelle Memorial Institute
Black & Veatch Mgmt Consulting LLC
Blue Frontier LLC
Brillio LLC
Brimstone Energy LLC
C H Robinson Company
California Institute of Technology
California State University Long Beach
Cherokee Nation Office Solutions
Clean Energy Systems Inc
Cleantech Group
Combined Power LLC
Connection
Czero LLC
DE Solutions
DNV GL USA INC
Dragonfly Vision
Electric Power Research Institute (EPRI)
Electrochaea Gmbh
Energy Experts International
Energy Solutions Center
Exponent Inc
Fluor Enterprises Inc
Frontier Energy, Inc.
Gas Machinery Research Council
Gas Technology Institute (GTI)
Genifuel Corporation
Geodetics Inc
Gladstein Neandross & Associates
ICF Incorporated LLC
Ingevity Corporation
Ips-Industrial Procurement Services
Johnson-Peltier
Kore Infrastructure LLC
Lawrence Livermore National Laboratory
Massachusetts Materials Technologies
Mcmaster Carr Supply Co
Michael Naylor
Microdrones Canada Inc
Nemaco Technology LLC
Northeast Gas Association
Nv5 Inc
Onboard Dynamics Inc
Onesource Distributors LLC
Operations Technology Development (OTD)
Opus 12 Inc
Our Powder Coating Inc
Pacific EH&S Services Inc
Parsons Environment & Infrastructure
PCPC Direct Ltd
Pipeline Research Council Intl Inc
Power and Telephone Supply Company
Quest Integrity Usa LLC
Quswami Inc
RM Myers Corporation
Restek Corporation
Ricardo Inc
Ricoh Usa Inc
Rr Donnelley
Sierra Energy
South Coast Air Quality Management District
Southwest Research Institute
Steve Cardiff
Summit Fluid Technologies LLC
Susteon Inc
Techcorr Usa Management LLC
Stanford University
The Grant Farm
The Sourcium Group
Transient Plasma Systems Inc
Tri-Pacific Supply Inc
Trussworks International Inc
UC Regents - University of California Irvine
UC Regents - University of California Berkeley
UC Regents - University of California Davis
UC Regents - University of California Riverside
University of Southern California
USAT Corp
Utilization Technology Development (UTD)
Western Office

Stakeholder Outreach

Organization	Title(s)
CEC	Energy and Fuels Program Manager
DOE	Technology Manager, Building Technologies Office (BTO)
DOE	Program Director, Advanced Research Projects Agency-Energy (ARPA-E)
DOE	Technology Manager, Bioenergy Technology Office (BETO)
GTI	Vice President, Energy Delivery & Utilization
GTI	Managing Director, Energy Delivery
UC Davis	Professor, Department of Mechanical and Aerospace Engineering
UC Davis	Founding Director, Institute of Transportation Studies
UC Irvine	Director, Adv. Power & Energy Program; Nat'l Fuel Cell Research Center; UCI Combustion Lab
UC Irvine	Director, Nat'l Fuel Research Center; Assoc. Dir, Advanced Power and Energy Program
UC Irvine	Director, UCI Combustion Laboratory
SCAQMD	Assistant Deputy Executive Officer
SCAQMD	Program Supervisor, Technology Advancement Office
SCAQMD	Air Quality Specialist
SCAQMD	Air Quality Specialist
SJVAPCD	Director of Strategies and Incentives
NYSEARCH	Executive Director
NYSEARCH	Program Manager
PG&E	R&D Innovation Manager – Gas Operations
PG&E	Technical Program Manager - RNG and Hydrogen

Key Collaborations

Industry Research Groups and Consortia

- Northeast Gas Association (NGA)/NYSEARCH
- Operations Technology Development (OTD)
- Pipeline Research Council International (PRCI)
- Sustaining Membership Program (SMP)
- Utilization Technology Development (UTD)

National Labs & Universities

- National Renewable Energy Laboratory (NREL)
- Pacific Northwest National Lab (PNNL)
- Lawrence Berkeley National Lab (LBNL)
- Lawrence Livermore National Lab (LLNL)
- Jet Propulsion Lab (JPL)
- Oakridge National Lab (ORNL)
- Caltech, Stanford, UCI, UCLA, and others.

Government Agencies and Businesses

- CPUC, CARB,
- Air Districts (SCAQMD, SJVAPCD),
- CalGEM (formerly DOGGR)
- EPA, CEC, DOE, DOT, PHMSA, ARPA-E
- DNV-GL, C-FER
- Microsoft, UPS, Walmart, Cummins
- **Many others**