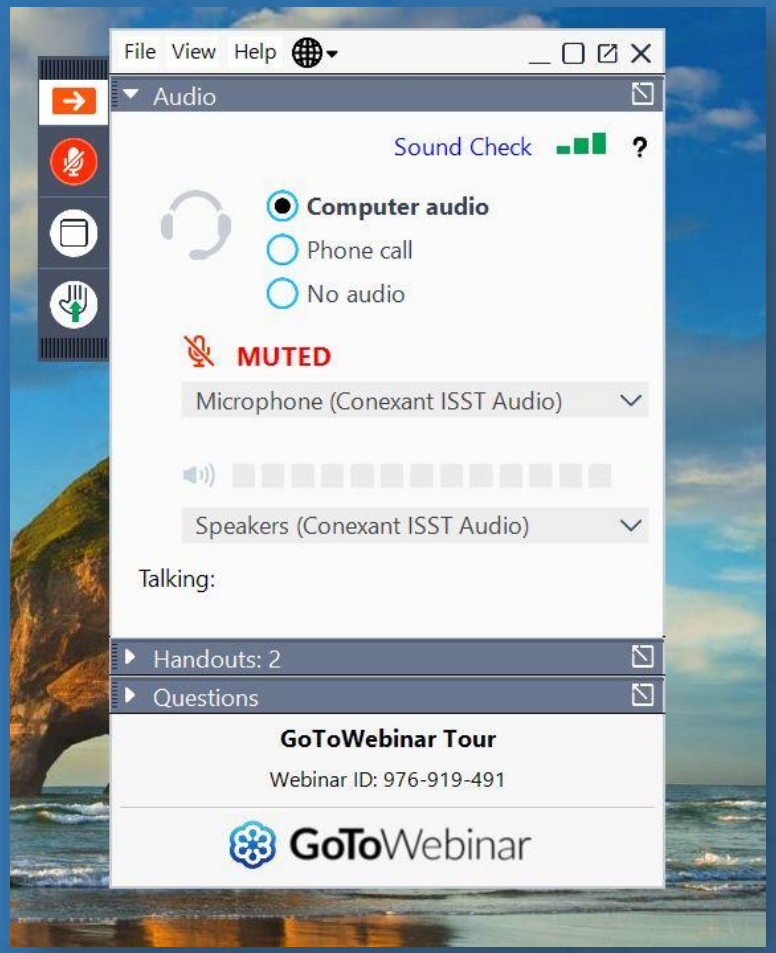
SoCalGas RD&D Program Spring Workshop

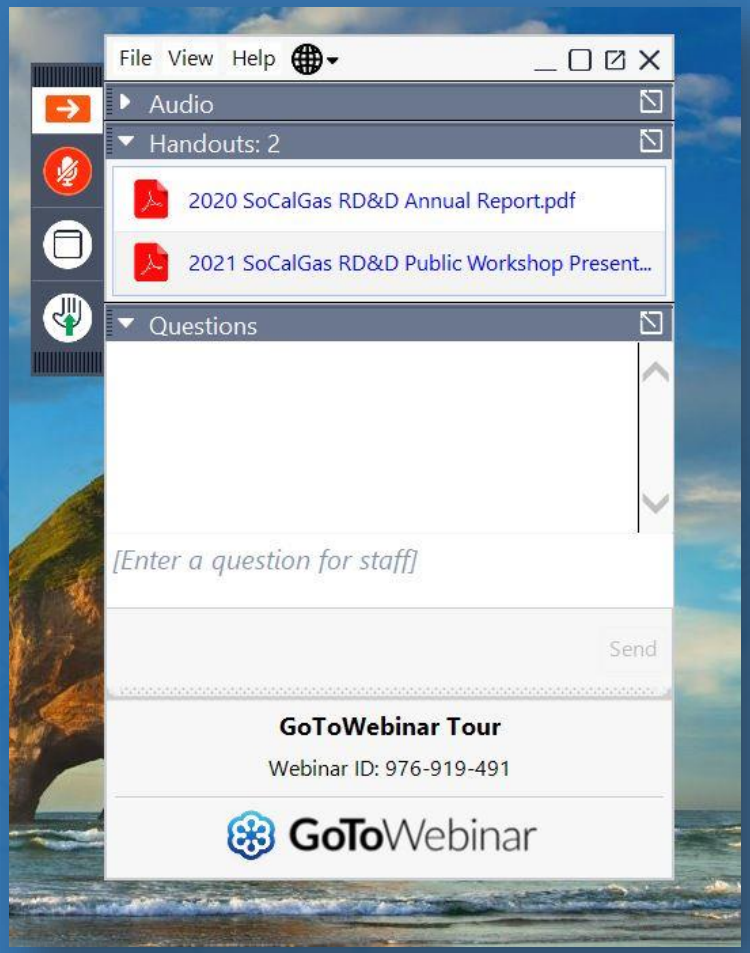
April 14, 2021

Meeting Notes

- Each topical 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/8514677156726274 68
- 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, April 30th to RDDinfo@socalgas.com.

GoToWebinar Tour





Presentation Objectives & Structure

Provide results from 2020

I. Input and guidance from CPUC in draft resolution
II. RD&D Overview and Structure
III. 2020 in Review

Give an update on 2021

IV. Status and Changes for 2021

Seek input for 2022

V. RD&D Plan Development
VI. Low Carbon Resources
VII. Clean Transportation
VIII. Clean Generation
IX. Customer End-Use
X. 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**

Safety Moment #1

To learn more about safety, visit:
https://www.socalgas.com/stay-safe/safety-and-prevention

20-20-20 Exercise

- Every 20 minutes
- Look at something 20 feet away
- For 20 seconds

Symptoms of eye strain:

- Dry eyes
- Watery eyes
- Blurred vision
- Double vision
- Headaches
- Soreness in the neck, shoulders, or back
- Sensitivity to light
- Trouble concentrating

Source: https://www.healthline.com/health/eye-health/20-20-20-rule

I. INPUT & GUIDANCE FROM CPUC RESOLUTION

CPUC Resolution G-3573

On March 18th, 2021, CPUC issued Resolution G-3573, approving SoCalGas' 2021 RD&D Research Plan.

Guidance for Subsequent RD&D Planning:

- Continue to increase transparency in:
  - Project area selection processes and criteria
  - Justification of consortia dues
  - Stakeholder outreach efforts
- Provide additional detail on engagement with CBOs
- Detail how future RD&D proposals align with California's transportation and building decarbonization goals
- Explain how SoCalGas has used (or intends to use) the results of the RD&D projects

II. 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.

OUR COMMITMENT TO DIVERSITY

At SoCalGas, our commitment to provide customers with safe, affordable, and reliable service goes beyond natural gas. We are also dedicated to improving the quality of life in the diverse communities we serve by maintaining a diverse workforce, working with suppliers that represent and reflect the communities we serve, and giving back through our charitable contributions and employee volunteer activities.

To support this commitment, SoCalGas RD&D staff conduct outreach efforts & activities to:

- Engage with disadvantaged and underrepresented groups throughout CA.
- Notify researchers, entrepreneurs, and businesses about RD&D Program funding opportunities.
- Share the results from RD&D projects to inform and educate the general public.
- Track and report progress in diversity outreach efforts in our Annual Report.

The vision, mission, and values of the SoCalGas Research, Development, and Demonstration Program align with SoCalGas' mission to build the cleanest, safest, and most innovative energy company in America.

OUR VISION

Advancing innovative technologies for safer, cleaner, and more reliable energy.

OUR MISSION

Identify transformational energy solutions. Build them. Share them with the world.

OUR VALUES

Science
Our experts in science, engineering, energy systems, and environmental policy seek answers to some of today's most pressing energy questions.

Synergy
We work with the world's finest researchers in universities, national labs, and industry to develop transformational technologies that support decarbonization, energy security, and economic development.

Equity
We champion technologies that support affordable access to clean, safe, and reliable energy for all Californians.

RD&D Goals

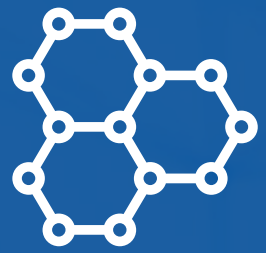
Identify, test, and develop new products and technologies for the gas delivery system that:

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

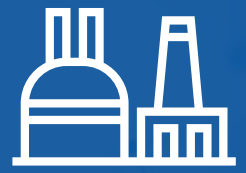
"With reliance on renewable energy sources growing every year, the decarbonization of the energy sector is well underway. SoCalGas is playing a pivotal role in this transformation by developing innovative clean energy innovations and energy efficiency technologies and advancing hydrogen for use in both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

–Maryam Brown, President, SoCalGas

Program Structure



Low Carbon Resources
Renewable Gas Production
Carbon Capture Utilization and Sequestration



Gas Operations
Environmental & Safety
Operations Technology
Systems Design & Materials
System Inspection & Monitoring

Clean Transportation
On-Road/Off-Road
Refueling Stations
Onboard Storage

Clean Generation
Integration & Controls
Distributed Generation

Customer End Use Applications
Commercial Food Services
Residential & Commercial Applications
Industrial Process Heat
Advanced Innovation


RELIABILITY
OPERATIONAL EFFICIENCY
SAFETY
PROGRAM BENEFITS
IMPROVED AIR QUALITY
REDUCED GHG EMISSIONS
IMPROVED AFFORDABILITY

Significant Resources & Capabilities

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

Differentiator

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

Key Collaborators

Complementary & Supplementary RD&D

Commercialization Partner for Industry

- Partner with successful research projects to ensure eventual commercial success.
- Build partnering teams and leverage SoCalGas resources.

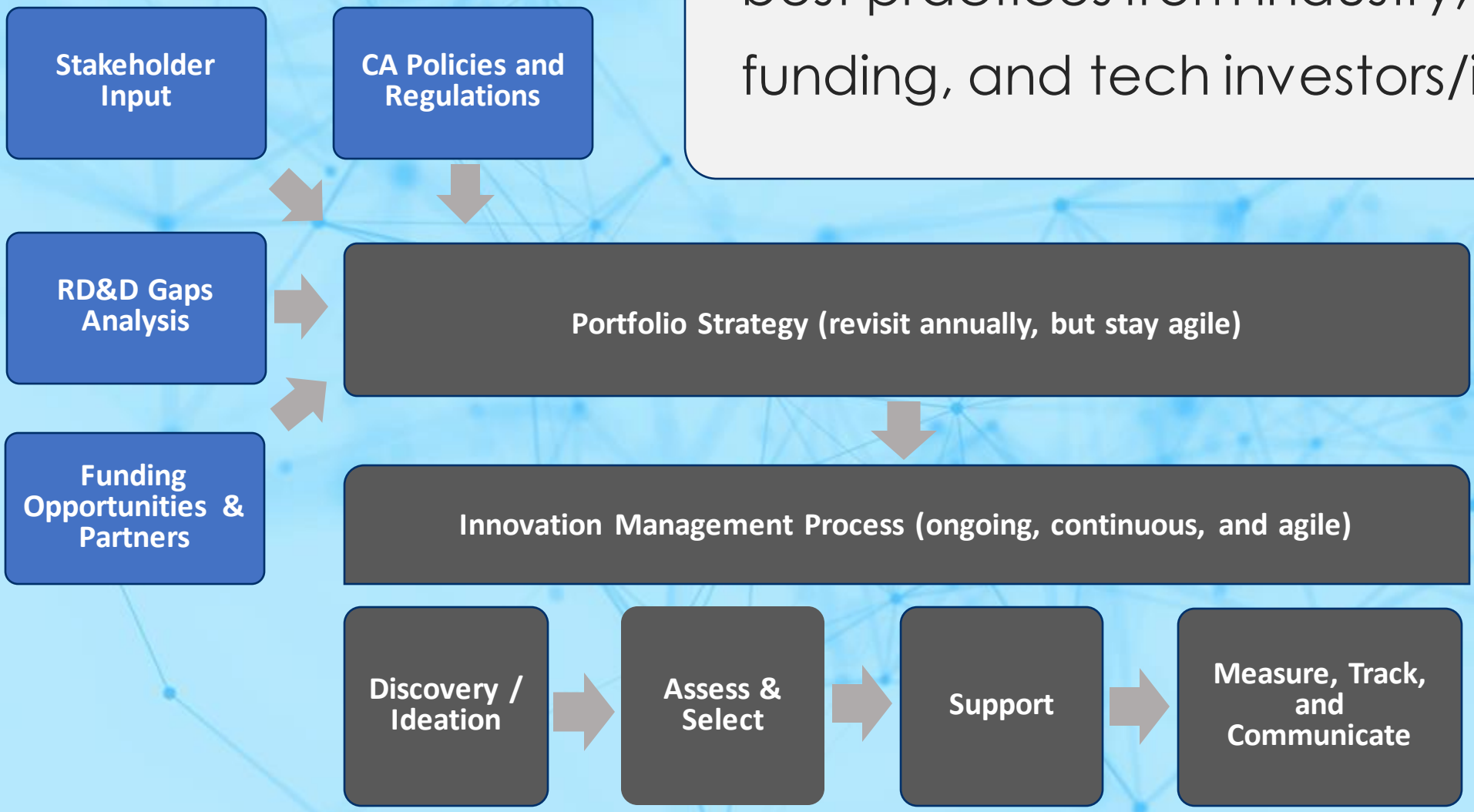
Leverage Diverse Sources of Funding

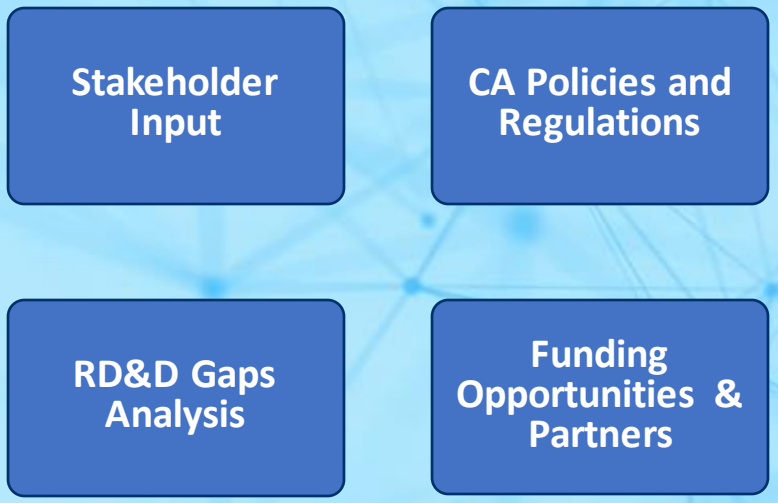
- Identify opportunities to co-fund RD&D projects and/or build collaborations to fully fund large projects.
- Target 3x leverage across the RD&D Program.

Agile Approach Targets 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.

The **Project Selection Process** builds on best practices from industry, DOE lab funding, and tech investors/incubators.





Project Concept Ideation

1. Assess Internal Operations Needs
2. Assess Customer Needs
3. Literature Surveys, Conferences, and Workshops
4. Research Consortia
5. External Funding Opportunities
6. Proposals from Researchers
7. Technology Roadmap Development
8. Public Workshops and Outreach

Assess & Select

Assess & Select Projects

Evaluation Criteria*

1. **Lead Investigator/Team**
2. **Technical Feasibility**
3. **Strategic Fit**
4. **Co-funding Collaborators**
5. **Commercialization Potential**
6. **Customer Benefit**
7. **Equity Considerations**

* In accordance with Public Utilities Code (PUC) 740.1

And now a short video

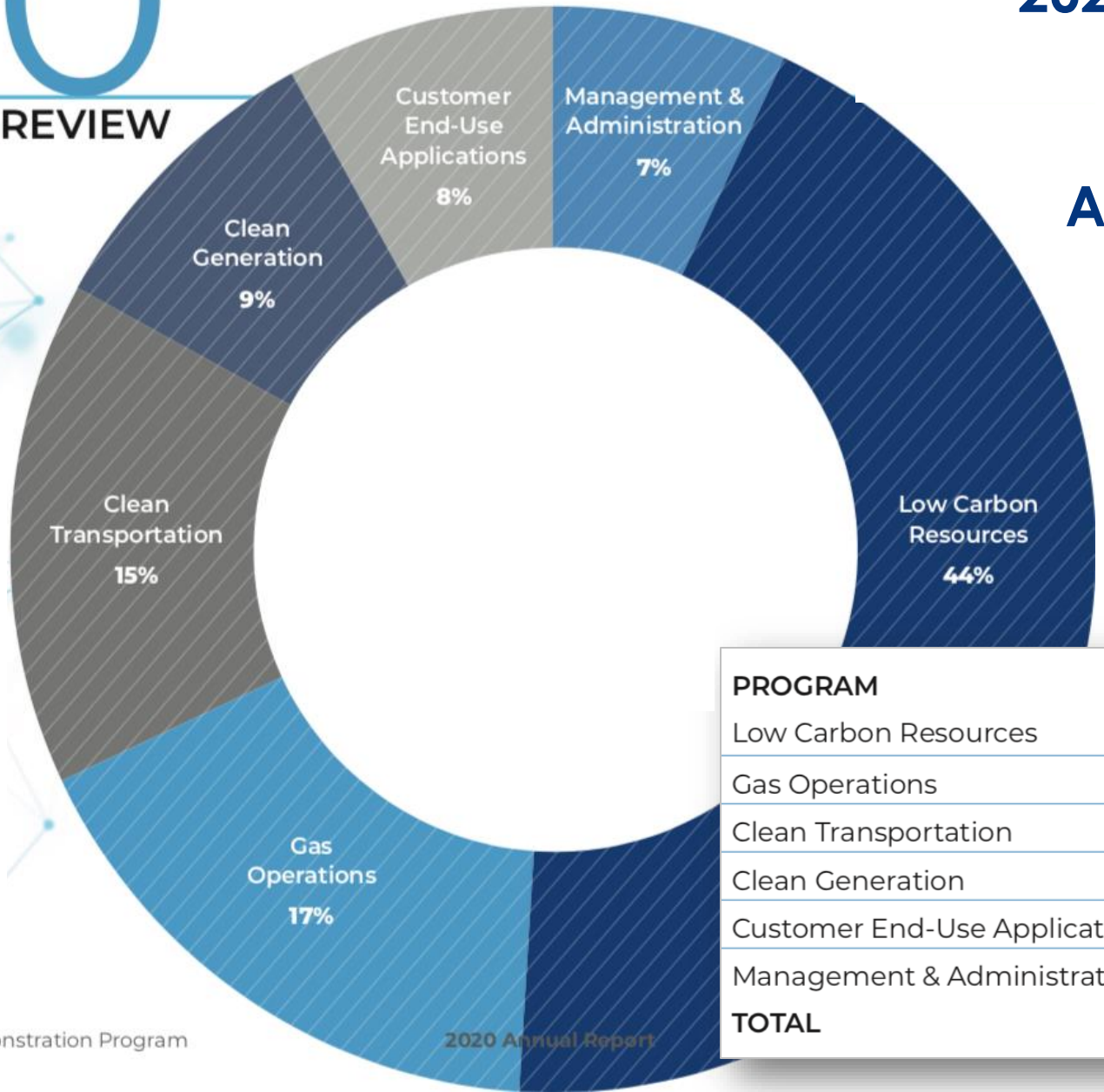
https://www.youtube.com/watch?v=Ibu6K1VxYGY

III. 2020 YEAR IN REVIEW

2020 IN REVIEW

FINANCIAL HIGHLIGHTS

2020 Actual Spend by Program Area and Administrative Costs



PROGRAM	2020 ACTUALS
Low Carbon Resources	$7,036,000
Gas Operations	$2,677,000
Clean Transportation	$2,363,000
Clean Generation	$1,442,000
Customer End-Use Applications	$1,376,000
Management & Administration	$1,149,000
TOTAL	**$16,043,000**

TOTAL ACTIVE PROJECTS IN 2020

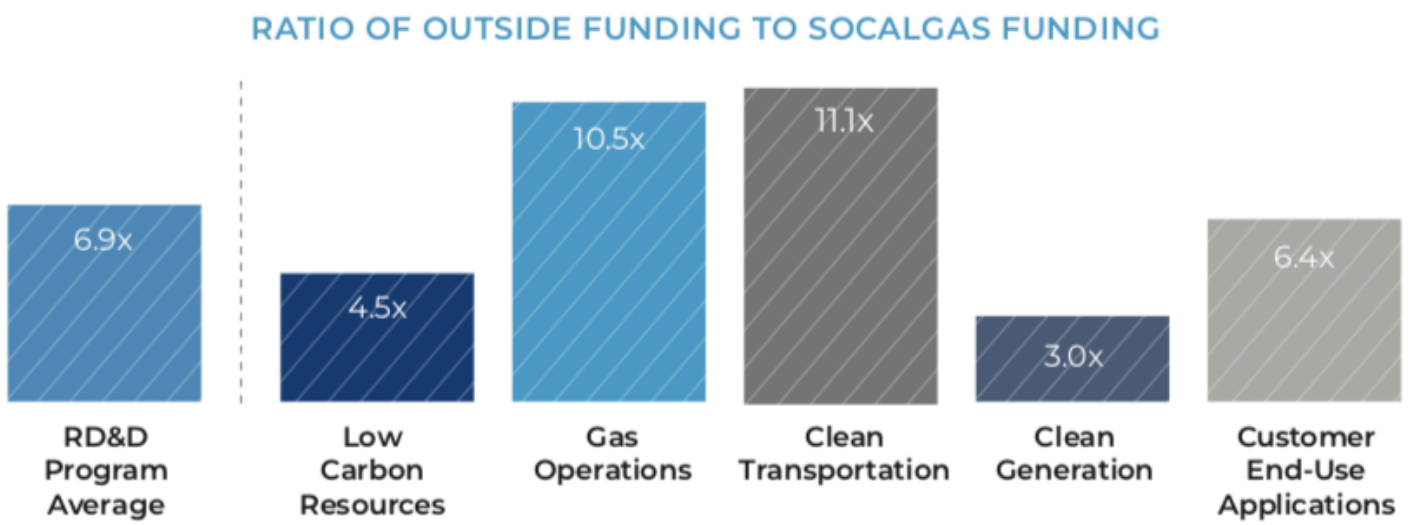
386

TOTAL INITIATED PROJECTS IN 2020

104

106

TOTAL PROJECTS COMPLETED IN 2020



Outside Funding Example:

5 Projects won a total of $11,922,984 from CEC in 2020

Equity Highlights

- Added equity considerations to our project evaluation
- Created a plan with Regional Public Affairs to connect with Community Based Organizations (CBOs) *(implementing now)*

Publications, Patents, and Citations in 2020

Projects co-funded or otherwise supported by the RD&D Program were:

- featured in 55 articles, reports, and technology briefs, and
- associated with four patent applications.

See the Appendix of the Annual Report for more information.

SoCalGas Supported Technologies Deployed in 2020

- Fracture Toughness via in-Ditch Non- Destructive Testing-Validation (PRCI NDE-2-9)
- Polyethylene Saddle Heat Fusion Rounding Clamp Evaluation
- Fiber Optical Systems at Montecito Creek
- Risk Profile for Aldyl-A Piping System - Phase 3 –Squeeze Off Reinforcement Clamps (OTD 2.13.d.3)
- Small Polyethylene Diameter Squeeze-Off - Phase 2 (OTD 2.14.c.2)
- Gas Utility Threat Contextualization (Real-Time Visualization and Notification)
- Demonstrate In-Line Inspection Tool for Gas Storage Piping
- Heavy Hydrocarbon Compound Dew Point in Natural Gas Pipelines (PRCI MEAS-15-01)
- Protect Tracer Wires from Corrosion (OTD 5.17.k)

Research Webinars

The RD&D Program staff conducted two webinars to share information with industry stakeholders, the research community, and the general public about two recent successful projects

1) Utilization of CO_2 Emissions to Make Renewable Fuels & Chemicals with Opus 12

- July 29, 2020
- Shared results of a 12-month research effort to develop electrochemical conversion of CO2 renewable fuels and industrial chemicals.
- 50 attendees, including LLNL, AGA, NASA, & PRCI.

2) Residential Gas-fueled Heat Pump Water Heaters with GTI

- December 10, 2020
- Presented results from field demonstration of 4th generation gas-fueled heat pump water heaters that reduce GHGs by 49%.
- 42 attendees, including PNNL, Rinnai, and San Diego Gas & Electric.

COVID-19 IMPACTS IN 2020

COVID-19 had an impact on several RD&D sponsored projects and collaborations.

- Funding for delayed projects was retained and shifted to 2021.
- The RD&D team worked with project managers and collaborators to adjust schedules for COVID-19 impacted projects.

2020 Annual Report

For more detailed information, see the RD&D Program's 2020 Annual Report.

Safety Moment #2

To learn more about safety, visit:
https://www.socalgas.com/stay-safe/safety-and-prevention

Call 8-1-1 before you dig

- Informational Video (30 sec)

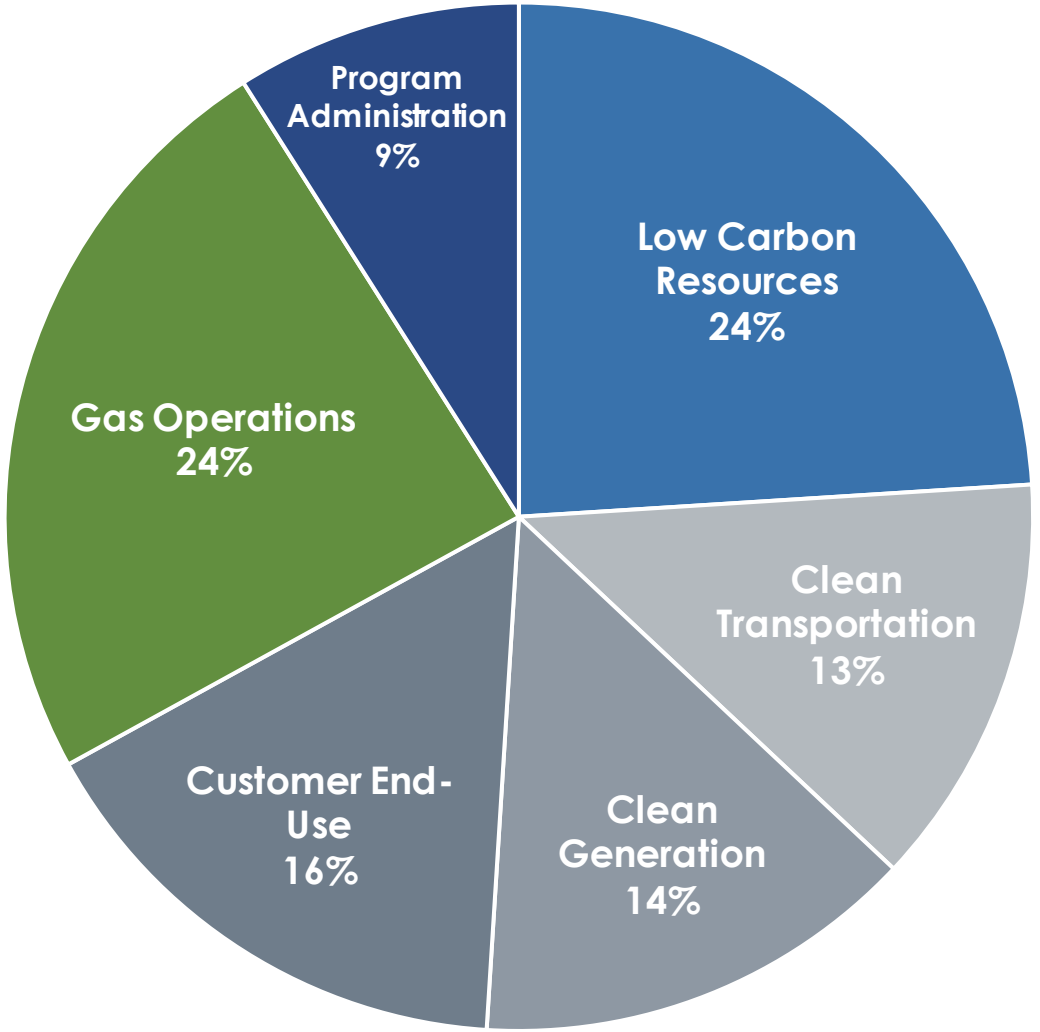
https://youtu.be/qmuX4W_PkLQ

IV. STATUS & CHANGES FOR 2021

APPROVED 2021 FUNDING ALLOCATION

*In accordance with Resolution G-3573, the planned 2021 funding allocation includes $2M rollover from 2020.

$18,192,900 in approved funding*



COVID-19 IMPACTS IN 2021

A good example of nimble RD&D in action

COVID-19 continues to have an impact on several projects and collaborations.

- **Some 2020 projects extended into 2021**
  - Kore Biosolids Pyrolyzer Field Test
  - Ingevity ANGP Ford F-150 Medium Duty Truck Demonstration
  - Universal Analytical Technique for Siloxane - Phase 2 (OTD 7.16.g.2)
  - Remote Gas Sensing For First Responders - Phase 4 (OTD 7.15.b.4)
  - CEPM for Turbochargers (PRCI CPS-14B-08)
- **Some 2021 projects and collaborations may also be shifted into 2022**

SoCalGas A Sempra Energy utility®

EQUITY ENGAGEMENT UPDATE

The RD&D team set a goal to conduct five community engagement sessions in 2020 and 2021.

Working with SoCalGas Regional Public Affairs, we have conducted two community engagement sessions:

1) **Session #1 – February 24th, 2021**
   - ✓ Representatives from 11 CBOs, including HomeAid OC, El Concilio Family Services, Black Voice Foundation, NAACP

2) **Session #2 – March 10th, 2021**
   - ✓ Representatives from 7 CBOs, including Asian Youth Center, Community Action Partnership of Kern, Greater Lakewood Chamber of Commerce

3) **Session #3 scheduled for May 19th, 2021**
   - ✓ Will focus on educational institutions: Community Colleges, CSUs, UCs, etc.

Feedback from the Community

Affordability

- ✓ "…affordability is a key concern."
- ✓ "Cost is number one for those we serve."
- ✓ "The clients we serve are extremely low-income. It is very valuable to provide housing options with reduced energy costs."
- ✓ "Affordability is the number one concern for our low-income constituents."

Efficiency as a cost-saving measure

- ✓ "…our clients who are majorly low-income are concerned about cost-saving and efficiency."
- ✓ "Low-income population is very concerned with pricing and efficiency."

Feedback from the Community

Reliability

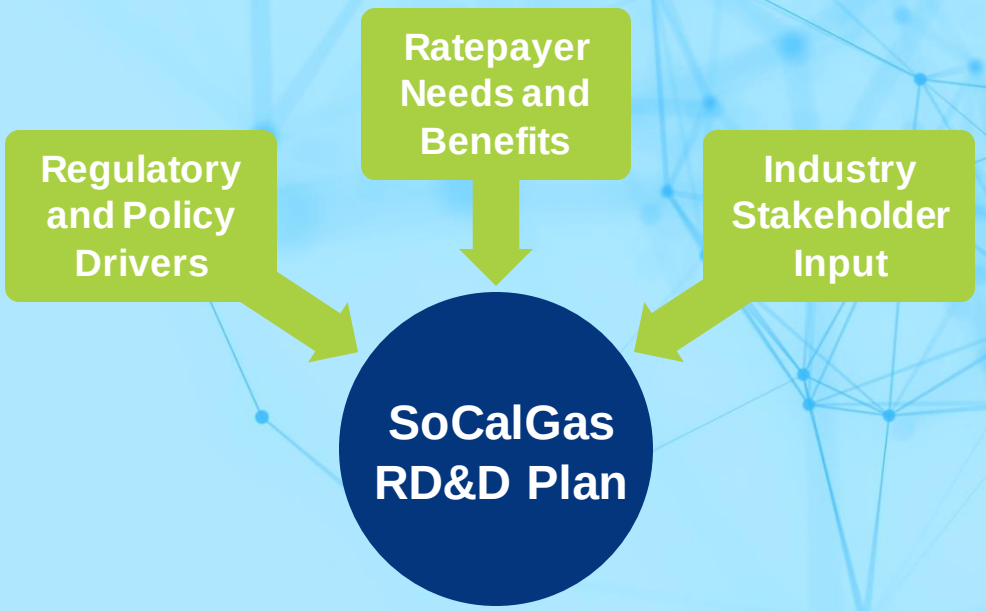
- ✓ "Many also have health concerns that require energy for medication storage or meal prep/heating options."
- ✓ "Reliability would be another concern."

Communication and Outreach

- ✓ "The type of work being done by the SoCalGas RD&D team… should be getting out to the public"
- ✓ "It would be great to share information with the ethnic press with translation to different languages…"
- ✓ "… making sure information is accessible for language communities."

V. RD&D Plan Development for 2022

THE RD&D PLAN FOR 2022



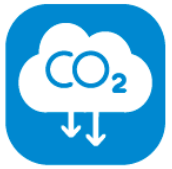
To build the RD&D Plan, program staff consider multiple factors, including:

1) **California Regulatory and Policy Drivers**
2) **Ratepayer Needs and Benefits**
3) **Input from knowledgeable industry stakeholders**
   - ✓ Universities, national labs, research consortia, public agencies, and businesses.

Regulatory & Policy Drivers

Category	Regulations & Policy Drivers
GHG Emissions	**SB32:** 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

Rate Payer Needs & Benefits



GHG Reduction

Reliability

Emissions Reduction

Safety

Cost Savings

Operational Efficiency

These Six Standard Benefits consider equity and social justice to ensure they **improve the lives of all SoCalGas Ratepayers**.

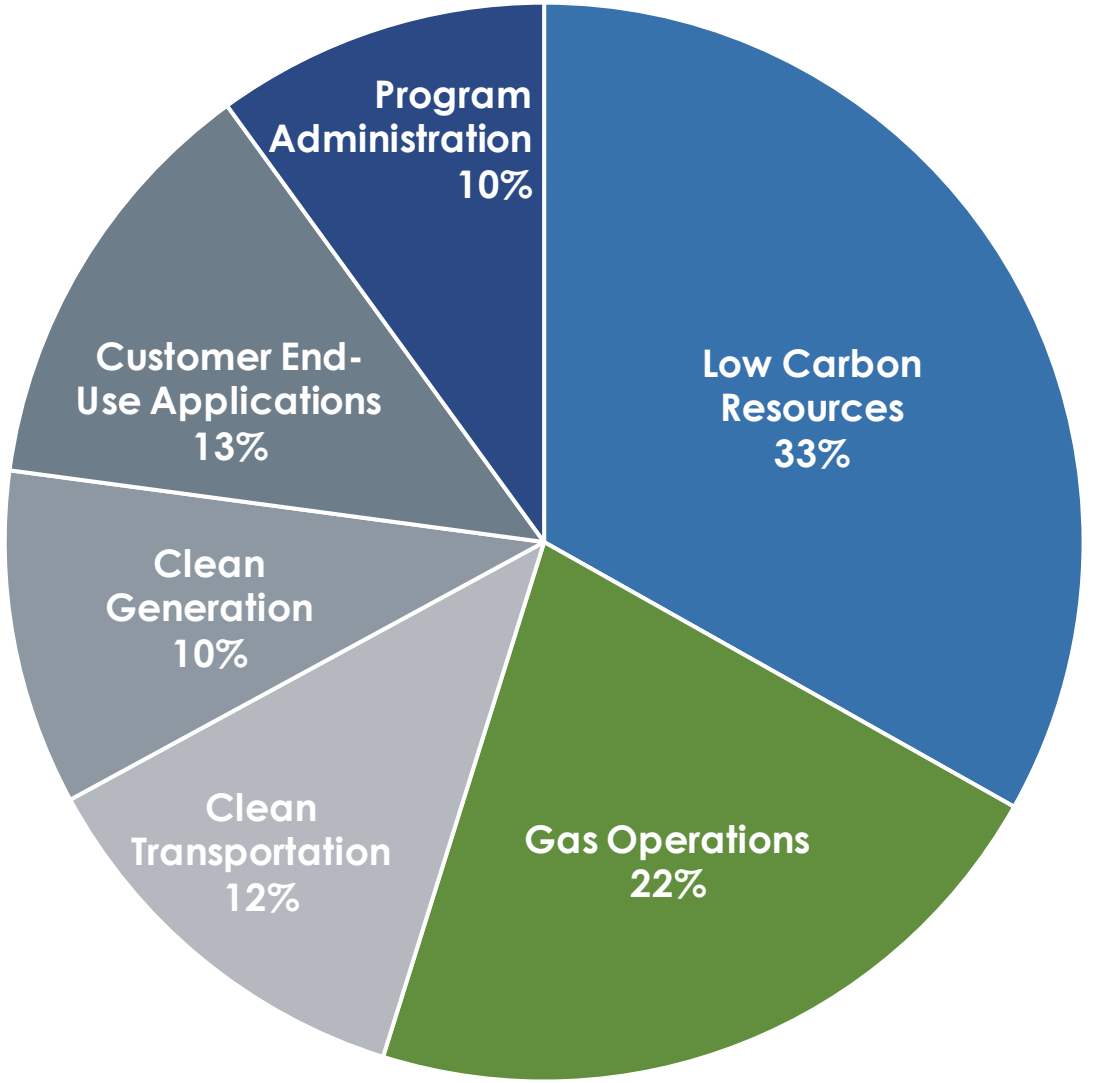
Stakeholder Input for Future RD&D Priorities

- Interviewed 56 people at 21 organizations
- Discussed technology area topics and program topics

PROPOSED 2022 FUNDING ALLOCATION

*Any over/underspend from 2021 will be applied to 2022 in accordance with Resolution G-3573.

$16,494,000* in total 2022 funding



Specific Areas We Would Like Feedback

1) Considering the Annual Report, this Workshop, Research Webinars, and Equity Engagement activities discussed, are there other ways we could share results from RD&D projects with the community?
2) When thinking about the 2022 RD&D Plan:
    a) Are there other stakeholders we should approach for feedback?
    b) What other high-level topics for 2022 would you like to hear about in the RD&D Plan document?
    c) Are there upcoming funding opportunities or partnership opportunities we should be aware of?

STRETCH BREAK!

Upper body and arms stretch

- ✓ Clasp hands together above the head with palms facing outward.
- ✓ Push your arms up, stretching upward.
- ✓ Hold the pose for 10 seconds.

Neck stretches

- ✓ Relax and lean your head forward.
- ✓ Slowly roll toward one side and hold for 10 seconds.
- ✓ Repeat on other side.
- ✓ Relax again and lift your chin back to starting position.

Torso stretch, or trunk rotation

- ✓ Keep your feet firmly on the ground, facing forward.
- ✓ Twist your upper body to the left, place your left arm on the back of your chair (if applicable), place your right hand on your left knee, and stretch.
- ✓ Hold pose for 10 seconds, repeat on other side.

V. Low Carbon Resources

- Overview & Goals
- Spotlight Projects
- Projects Approval Process
- Sub-Programs Overview
- Renewable Gas Production
- Carbon Capture Utilization and Sequestration (CCUS)
- 2022 Proposed Funding Allocation
- Specific Areas We Would Like Feedback

SoCalGas

Overview & Goals

The Low Carbon Resources RD&D Program develops and demonstrates technical solutions that can **expand the production and use of renewable natural gas and hydrogen** to replace conventionally-sourced gas while **offsetting and removing GHG from the atmosphere**

Goals

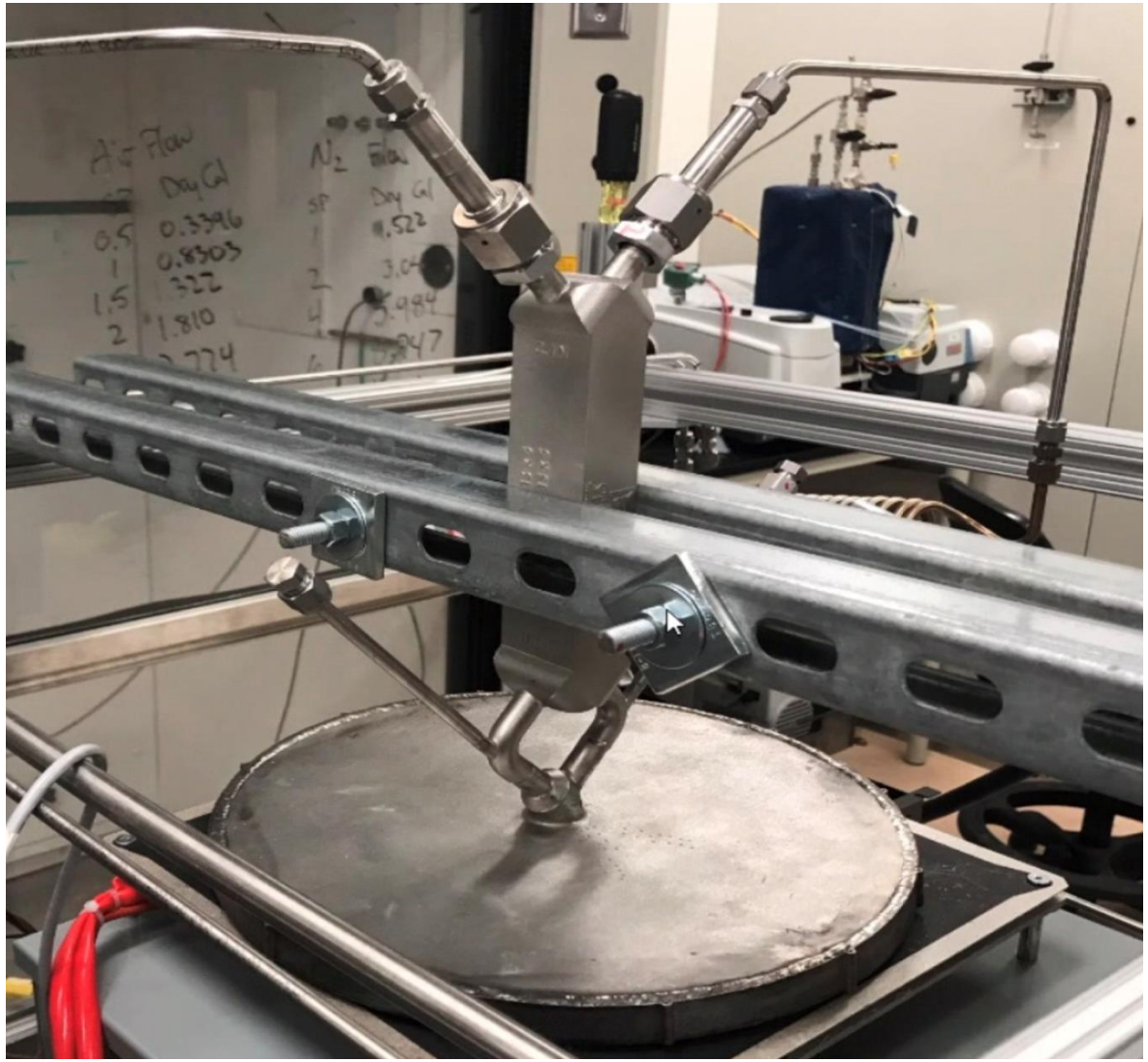
- Increase the availability of renewable gas and promote pipeline decarbonization solutions by advancing production technologies that diversify renewable gas feedstocks and pathways
- Offset emissions from conventional natural gas use by capturing and permanently removing atmospheric GHG emissions through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

Spotlight Projects

STARS Corporation Electric Induction Steam Methane Reforming (SMR) Equipment Purchase for Demonstration Project

Total Project Cost	$2,175,000
Start → Finish	4/1/2020 - 12/31/2022
Participants	STARS Corporation, PNNL

SoCalGas and STARS Technology Corporation are collaborating to develop the first end-to-end demonstration of commercial hydrogen generators based on Steam Methane Reforming (SMR) technology of biomethane using a novel modular, advanced, 3D printed, microchannel reactors and heat exchangers. Unlike traditional combustion-driven SMR processes, these advanced units will rely on a combustion-free, induction heating mechanism to produce hydrogen from biomethane and steam with record conversion efficiency. These modular units can be deployed at point-source hydrogen users for self-generation.



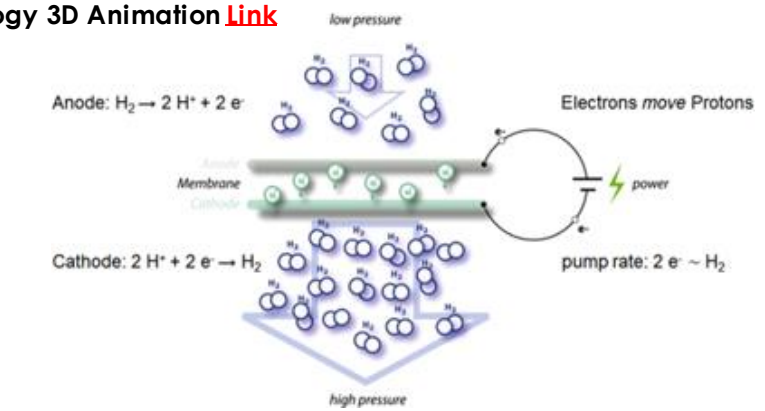
Spotlight Projects

H2 PURECOMP-- Electrochemical Hydrogen Compression and Purification Skid Procurement

Total Project Cost	$540,000
Start → Finish	03/09/2020 - 07/31/2021
Participants	HyET Hydrogen USA, LLC

HyET's Electrochemical Hydrogen Purification & Compression (EHPC) technology is based on selective transport of Hydrogen through a Membrane Electrode Assembly (MEAs). This technology can be used to purify hydrogen from a blended natural gas stream and compress it up to storage and dispensing pressures. Delivery, installation, commissioning and demonstration of this 10 kg/day system is planned to start in April/May 2021 at SoCalGas' Engineering Analysis Center. To test the technology, SoCalGas will blend hydrogen, in concentrations from 3 to 15%, with methane, in a simulated pipeline environment, then extract and compress it.

HyET Technology 3D Animation Link



Spotlight Projects

Direct Air Capture Using Novel Structured Adsorbents

Total Project Cost	$3,414,202
Start → Finish	10/01/2020 – 09/30/2023
Participants	Electricore, Svante, Climeworks, Wintec, DOE

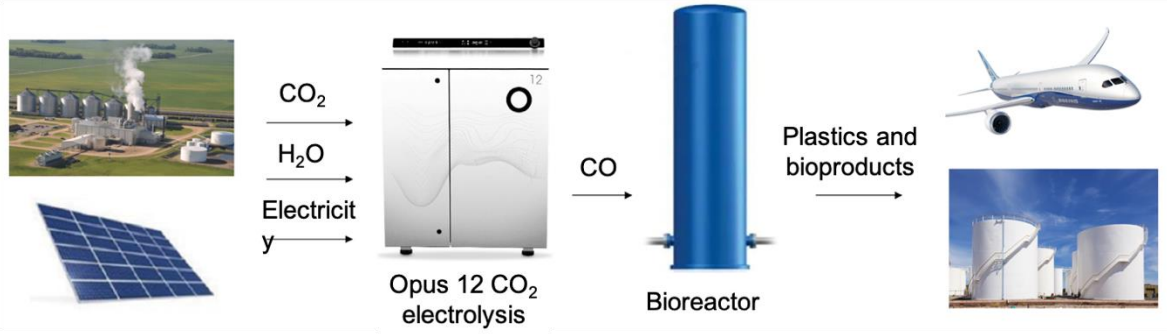
This project aims to construct and operate an integrated Direct Air Capture (DAC) system in Palm Springs, CA, and testing a novel combination of Climeworks' DAC process and hardware with Svante's structured adsorbent laminate filter, advancing the process and identifying optimization options for this DAC configuration. The main goal is to address identified technical barriers on an existing DAC system to drive down DAC cost to US$140/tCO2 for a 1 MMt/y plant that produces a concentrated CO2 stream with at least 95% purity.

Spotlight Projects

PEM CO2 Electrolyzer Scale-up to Enable MW-Scale Electrochemical Modules

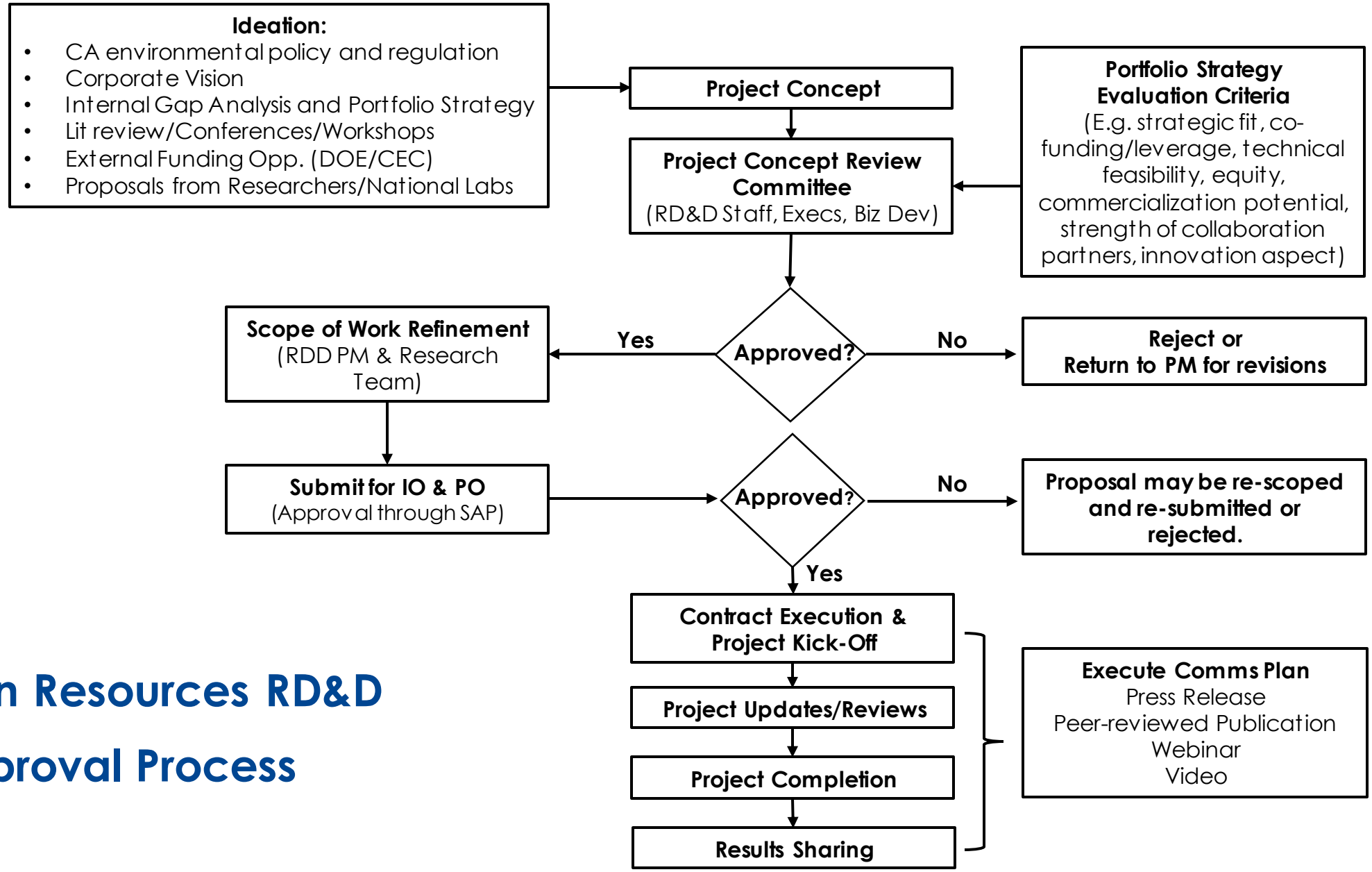
Total Project Cost	$3,125,000
Start → Finish	11/30/2020 - 08/31/2022
Participants	Opus 12, DOE BETO, NEL, LBNL, NREL, UConn, UToronto

Opus 12 has achieved state-of-the-art performance for CO2 electrolysis to carbon monoxide (CO) in their commercial "dishwasher" system. However, scaling up the PEM CO2 electrolyzer system to MW-scale is necessary to enable industrially relevant applications where tremendous amounts of CO2 can be converted into CO and subsequently plastics and bioproducts. The next step in technology development is scaling up the Membrane Electrode Assembly (MEA) active area to 1,600 cm2. This MEA area is needed to build MW-scale stacks capable of over 800 kgs of CO2 conversion per day per MW of energy input and develop a path to commercialization



Low Carbon Resources RD&D

Project Approval Process



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LCR Sub-Programs

2021

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

2022*

- Renewable Gas Production
- Carbon Capture Utilization and Sequestration (CCUS)

***Proposed new sub-programs to reflect stakeholder feedback and better align with the broader research community and CA policy**

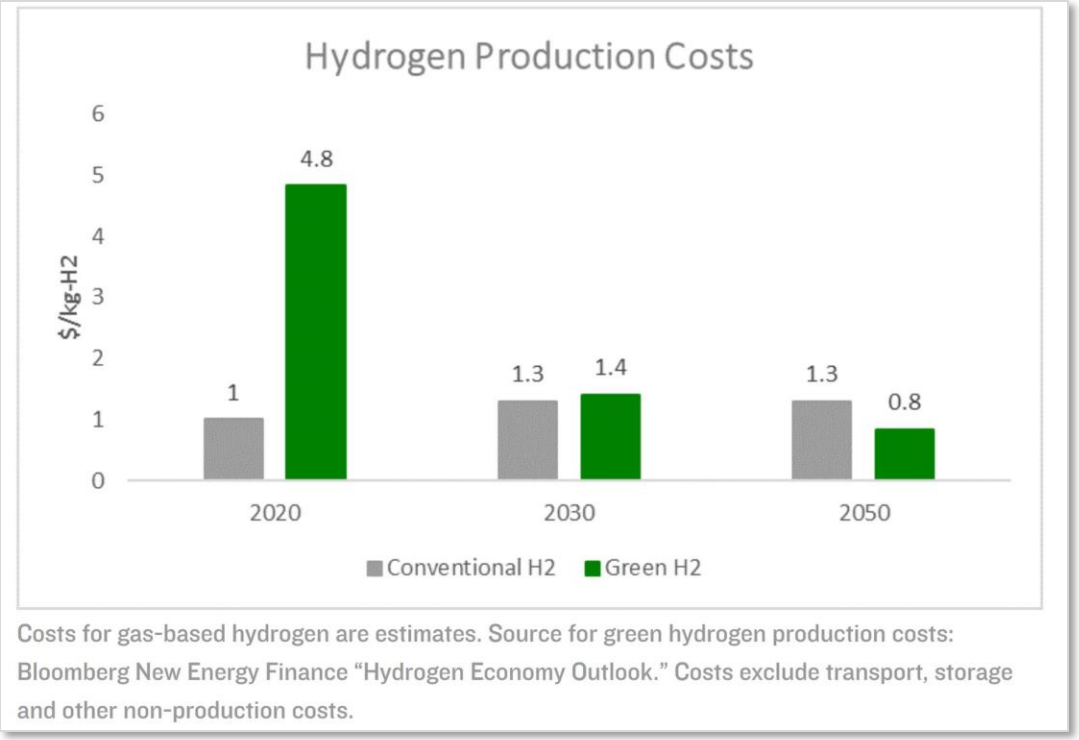
Renewable Gas Production

Background

Purpose

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

> **"Hydrogen is today enjoying unprecedented momentum. The world should not miss this unique chance to make hydrogen an important part of our clean and secure energy future."**
>
> IEA, "The Future of Hydrogen"



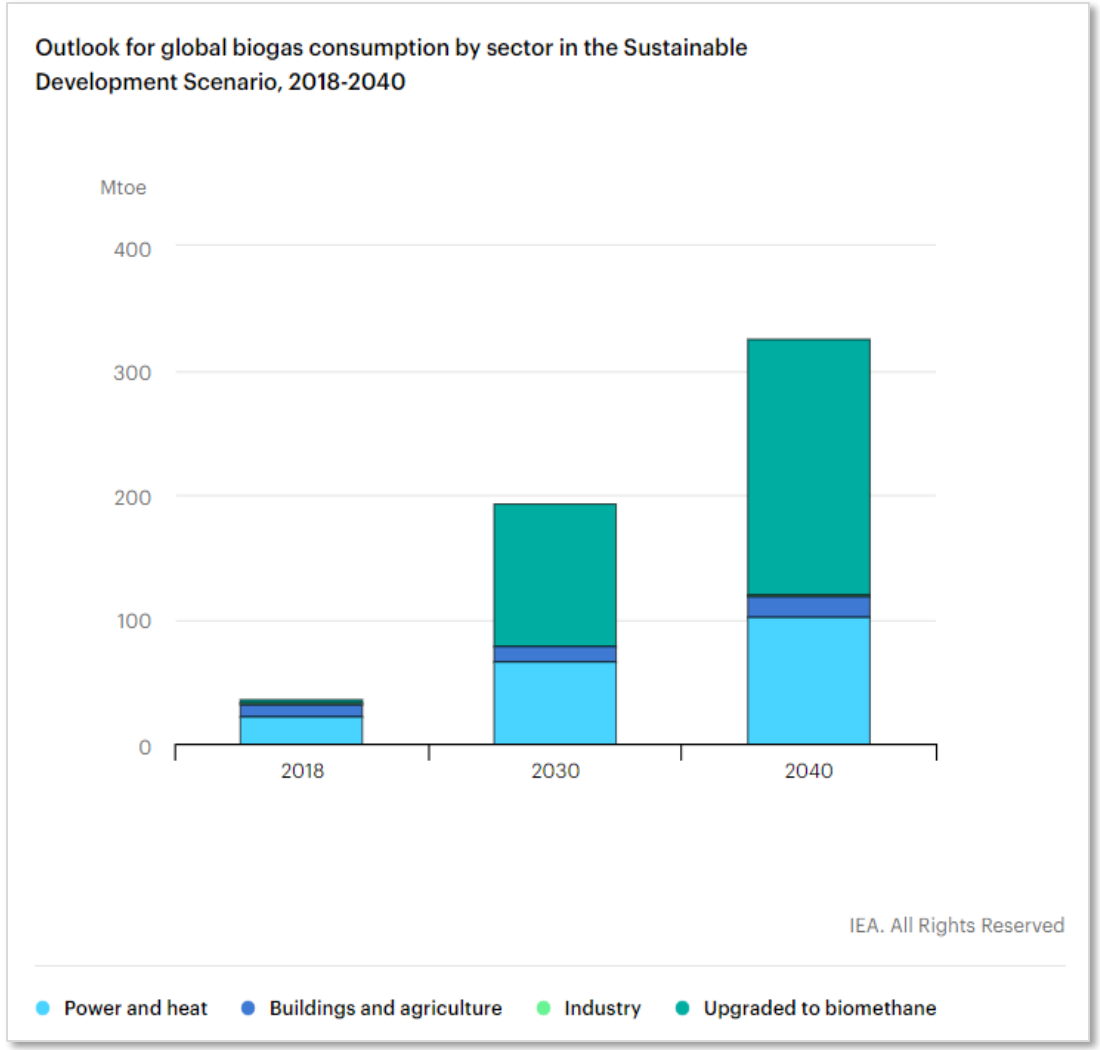
Bloomberg New Energy Finance

Renewable Gas Production

Background

"EPA encourages the recovery and beneficial use of biogas as a renewable energy resource, including the production of renewable natural gas (RNG) when feasible, as a means of reducing emissions and providing other environmental benefits." EPA

"[EERE and the Fossil Energy (FE) group] are working to reduce the cost of producing hydrogen via steam methane reforming. EERE is focused on innovative technologies for distributed hydrogen production from natural gas and bio-derived feedstocks. " DOE Hydrogen Program



International Energy Agency (IEA)

Renewable Gas Production

Research Areas

- Renewable hydrogen production via advanced water-splitting
- Renewable methane production via various methanation pathways
- Renewable gas production via biomass gasification
- Distributed hydrogen production via advanced Steam Methane Reforming (SMR) of biomethane
- Concentrated Solar Power (CSP) technology for renewable gas production

Technical Targets

- U.S. demand estimated to be up to 63 MMt H2/year by 2050. NREL
- Renewable hydrogen production to drop below $2/kg by 2030 for mass market adoption. International Renewable Energy Agency (IRENA)

Renewable Gas Production

Benefits

GHG Benefit

Pipeline decarbonization by displacing fossil-sourced gas can reduce, mitigate or eliminate GHG emissions.

Emissions Benefit

Replacement of fossil-sourced gas with renewable hydrogen can improve air quality, especially in industrial zones.

Cost Savings Benefit

The development of technologies and innovations that produce renewable gas at the lowest possible cost would result in increased affordability and accessibility of renewable gas to ratepayers.

Reliability

The gas grid can improve energy reliability by absorbing curtailed power and synchronizing energy supply with demand, e.g. Instead of curtailment, renewable energy can be channeled to make hydrogen for pipeline injection and long duration storage.

Safety

Self-generation of hydrogen at point-users eliminates the need to transport hydrogen from centralized production points in high-pressure cylinders/vessels and makes hydrogen adoption inherently safer.

Renewable Gas Production

Key Considerations

Policy Alignment

Renewable gas production aligns and conforms with California's decarbonization goals through its direct relevance and applicability to several key policies.

By reducing the carbon-intensity of the gas grid through its gradual decarbonization, this sub-program supports the following policies:

- AB 3232 (Building Decarbonization)
- EO B-55-18 (2045 Carbon-neutral California economy)
- Clean Air Act (Air quality standards for NOx and PM)
- SB 32 (Regulating and monitoring GHG emission sources)
- EO S-3-05 (GHG emission reduction targets)
- SB 1383 (CH4 emissions from organic waste)
- LCFS (Reduce carbon intensity of fuels)
- AB 8 (Development of100 H2 Stations in CA)
- EO B48-18 (200 hydrogen refueling stations by 2025)

Equity

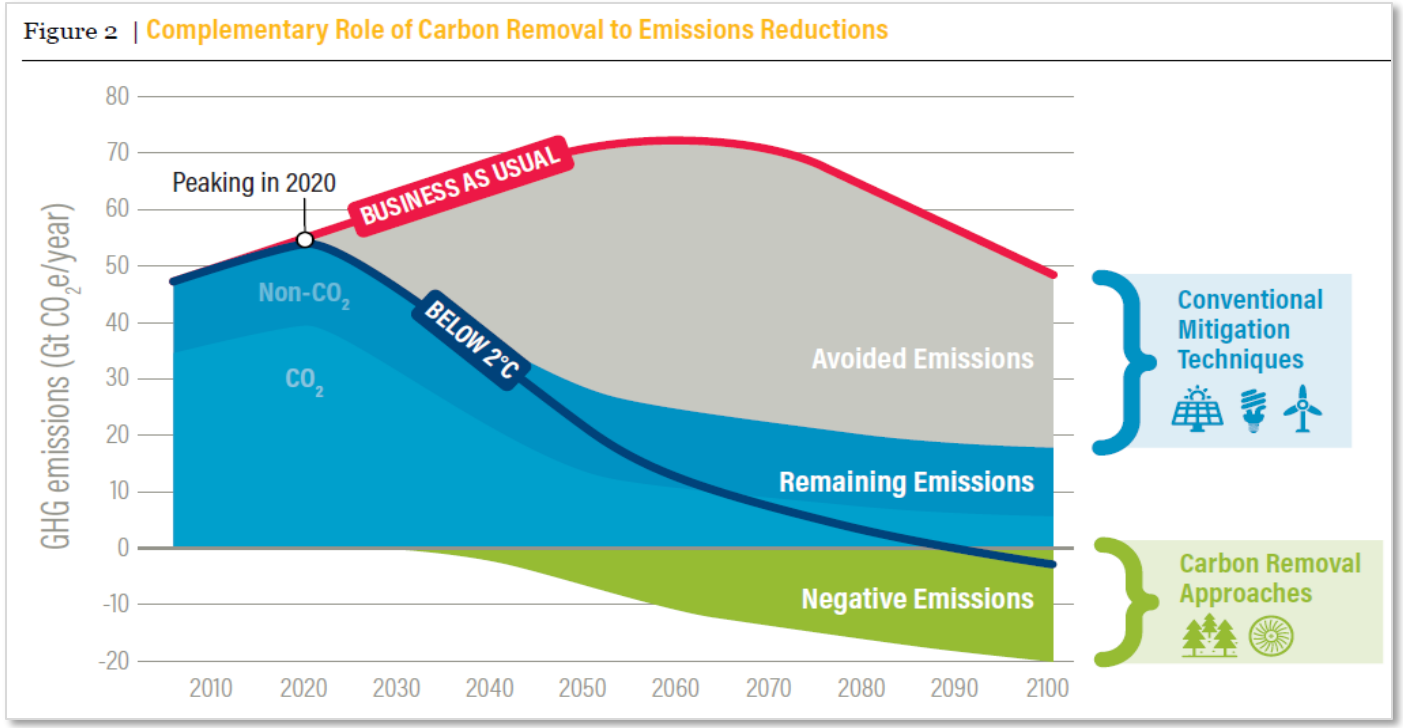
By decarbonizing the pipeline and replacing its fossil-sourced content with renewable gas, this sub-program would reduce emissions and improve air quality in areas neighboring industrial facilities, most of which fall within low or disadvantaged communities*, in alignment with **CPUC ESJ Action Plan.**

> **CPUC ESJ Action Plan Goal 2**: Increases investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health
>
> *According to CalEnviroScreen 3.0

Carbon Capture Utilization and Sequestration
Background

Purpose

CCUS is vital in the fight against climate change. Not only is it imperative to modify the production sources for gas and transition to renewable ones, but offsetting emissions by capturing, utilizing or sequestering CO2 from our atmosphere (negative emissions technologies) and industrial processes is critical to mitigate and reverse the effects of climate change.

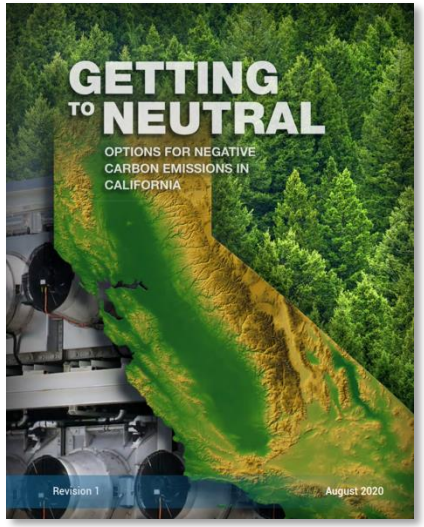


World Resources Institute

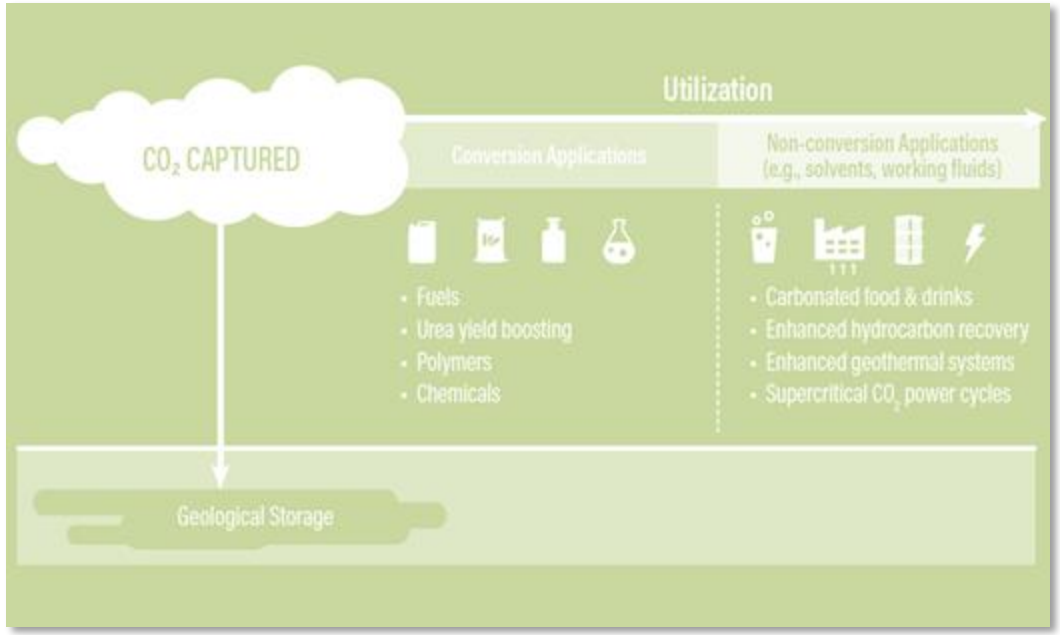
CCUS
Background

"C-Zero raises $11.5 million for methane pyrolysis"
ACS.org, C-Zero raises $11.5 million for methane pyrolysis"

"For industry, CCUS technologies are among the cheapest abatement options – or the only option" IEA, "Is carbon capture too expensive?"



"[To reach carbon neutrality by 2045] California will likely have to remove on the order of 125 million tons per year of CO2 from the atmosphere."
LLNL, "Getting to Neutral"



World Resources Institute

"Department of Energy Invests $72 Million in Carbon Capture Technologies" DOE, energy.gov

CCUS
Research Areas

- Carbon Capture and Utilization (CCU)
  - e.g. Direct Air Capture (DAC) coupled with conversion of CO2 into plastics, cement, and biofuels
- Carbon Capture and Sequestration (CCS)
  - e.g. DAC coupled with compression and storage of CO2 in depleted oil fields and saline aquifers
- Emissions-free hydrogen production via methane pyrolysis
  - e.g. Bubbling methane into a molten solution to decompose it into solid elemental carbon for a variety of uses and hydrogen

Technical Targets

- Post combustion capture: $30/t-CO2 captured by 2035. PNNL, "Cheaper Carbon Capture is on the Way"
- Direct Air Capture: $100/t-CO2 captured by 2030. Nature, "Sucking carbon dioxide from air is cheaper than scientists thought"

CCUS Benefits

GHG Benefit

CCUS systems can permanently remove CO2 from the air, resulting in negative overall carbon emissions. Additionally, emissions-free hydrogen production from methane pyrolysis can further decarbonize the pipeline and reduce its associated GHG emissions

Emissions Benefit

Hydrogen produced from methane pyrolysis can improve air quality.

Reliability

Leveraging synergies between renewable energy, carbon capture, and RNG production from captured CO2 through methanation processes can help improve system reliability and reduce reliance on out-of-state gas resources.

CCUS
Key Considerations

Policy Alignment

Carbon capture can help CA reach its ambitious decarbonization and climate change mitigation goals more expeditiously by not only offsetting emissions from various GHG-emitting sectors, but also by creating a circular and carbon negative economy.

CCUS can support various CA policies and regulations:

- AB 3232 (Building Decarbonization)
- EO B-55-18 (2045 Carbon-neutral California economy)
- Clean Air Act (Air quality standards for NOx and PM)
- LCFS (Reduce carbon intensity of fuels)
- AB 8 (Development of 100 H2 Stations in CA)

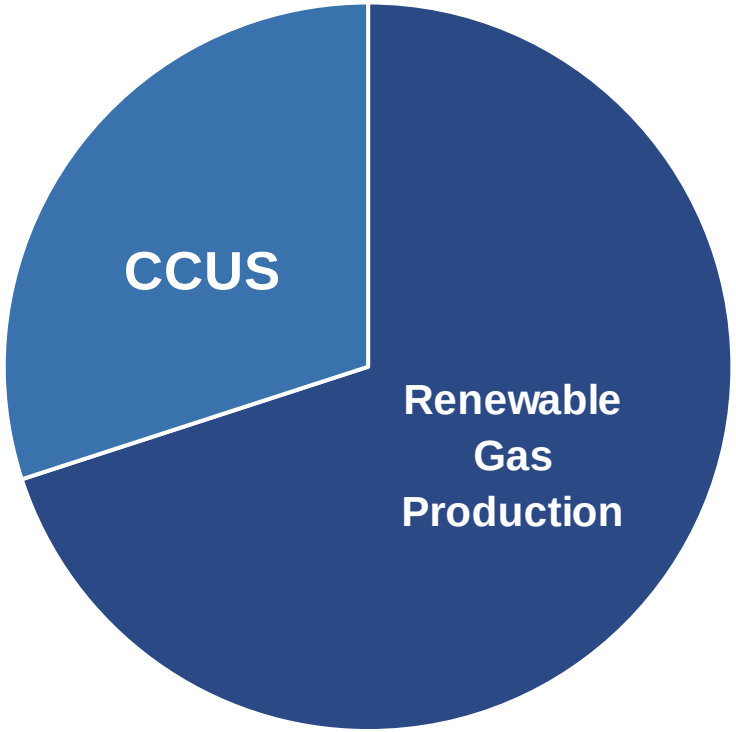
Equity

Deployment of carbon capture technologies near industrial facilities, most of which in low-income and disadvantaged communities*, can improve the air quality of those communities. Additionally, hydrogen from methane pyrolysis can be used directly to provide emissions free energy in hard to decarbonize industries, such as steel and aluminum, which are also located in low-income and disadvantaged communities.* These benefits to ESJ communities are in line with Goal 2 of the CPUC ESJ Action Plan.

> **CPUC ESJ Action Plan Goal 2**: Increases investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health

*According to CalEnviroScreen 3.0

2022 Proposed Funding Allocation



Sub-Program	Allocation
Renewable Gas Production	70%
CCUS	30%
Total	**$5,492,502**

Specific Areas We Would Like Feedback

1. Do you agree with the reclassification of research areas that were previously under low-carbon hydrogen as we restructured our proposed sub-programs from three in 2021to two in 2022?
2. Besides cost, what do you think are some of the technical obstacles to the deployment of DAC technology at scale?
3. How big of an impact can hydrogen extraction technology have on kick-starting the hydrogen economy and disrupting the centralized hydrogen production model?
4. FortisBC announced last year that it plans to purchase one million gigajoules of RNG made from wood waste annually. California has tremendous biomass resources. How can we best leverage that feedstock to produce renewable gas? What are the technology gaps that need to be addressed?
5. What are your thoughts regarding the future of direct water-splitting technology (e.g., sunlight-driven or biological) compared to conventional water electrolysis?
6. Methane pyrolysis is a potentially exciting pathway to simultaneously produce hydrogen and capture/utilize carbon. How can we accelerate R&D and innovation in this research area?

15-MIN BREAK

The next session will start at 11:15am

- ✓ Please take some time to move around, stretch, and rest your eyes.

VI. Clean Transportation

- Overview & Goals
- Spotlight Projects
- Project Approval Process
- Sub-Programs Overview
- On-Road
- Off-Road
- Refueling Stations
- Onboard Storage
- 2022 Proposed Funding Allocation
- Specific Areas We Would Like Feedback

SoCalGas

Overview & Goals

The Clean Transportation RD&D Program focuses on minimizing environmental impacts related to the transportation sector.

Goals

- Zero-emission transportation technologies
- Zero- and near-zero emissions fueling infrastructure
- Advanced on-board storage technologies

Spotlight Projects

Hydrogen Fuel Cell Yard Truck Port of Los Angeles Demonstration

Total Project Cost	$12,055,413
Start → Finish	1/1/2019 - 12/31/2021
Participants	CARB, GTI, Frontier Energy, REV Group, BAE, Ballard, HTEC, TraPac

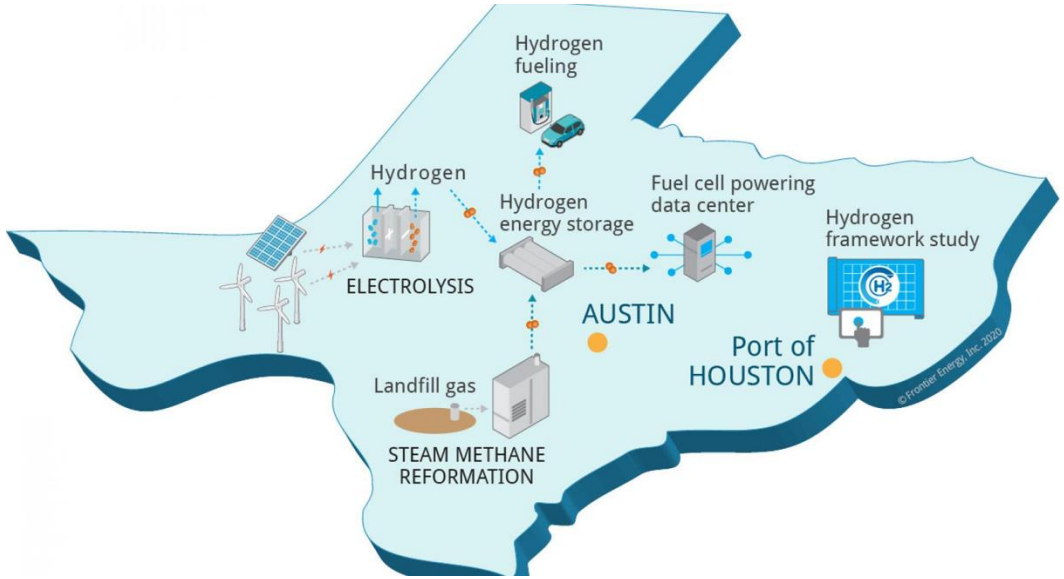
The objective of the proposed yard truck deployment is to develop and demonstrate the reliability, performance, durability and total cost of ownership of yard truck fleet in operation at the Port of Los Angeles. This deployment and demonstration is the first of a kind and will pave the way for similar future technologies in this space. There will be an extensive technology showcasing effort in order to maximize the impact of the demonstration. The project is intended to demonstrate to port terminal operators that fuel cell powered, zero-emissions yard trucks is a safe, reliable, and operationally preferable solution to meet the port's clean air action plan.

Spotlight Projects

H2 at Scale Hydrogen Refueling Demonstration

Total Project Cost	$10,800,000
Start → Finish	11/01/2019 - 12/31/2021
Participants	DOE, GTI, Frontier Energy, UT Austin, One Gas, One H2, Air Liquide, others

The H2@Scale project will develop and demonstrate the co-location of multiple hydrogen generation and multiple hydrogen use applications along with research and outreach, to develop a framework for additional H2@Scale pilot opportunities.

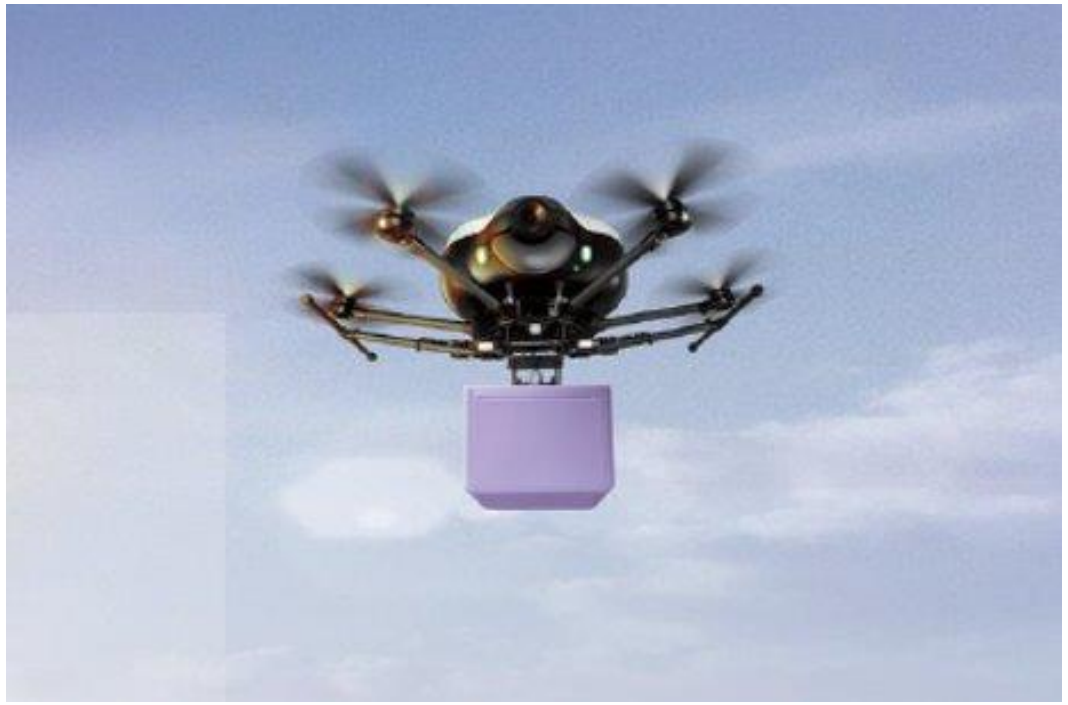


Spotlight Projects

Hydrogen Drone Demonstration

Total Project Cost	$250,000
Start → Finish	09/30/2020 – 12/31/2021
Participants	GTI, Doosan Mobility Innovation

This project aims to demonstrate the Doosan Mobility Innovation (DMI) technology to advance hydrogen for drones for commercial applications such as package delivery, law enforcement, and utility pipeline inspection. GTI will work with DMI to provide a subject matter expert (SME) (or experts, as needed) to support a demonstration of DMI drones and provide an assessment of DMI's hydrogen infrastructure plans, with specific focus on fueling sites and repair/maintenance facilities for its fuel cell drone operations.

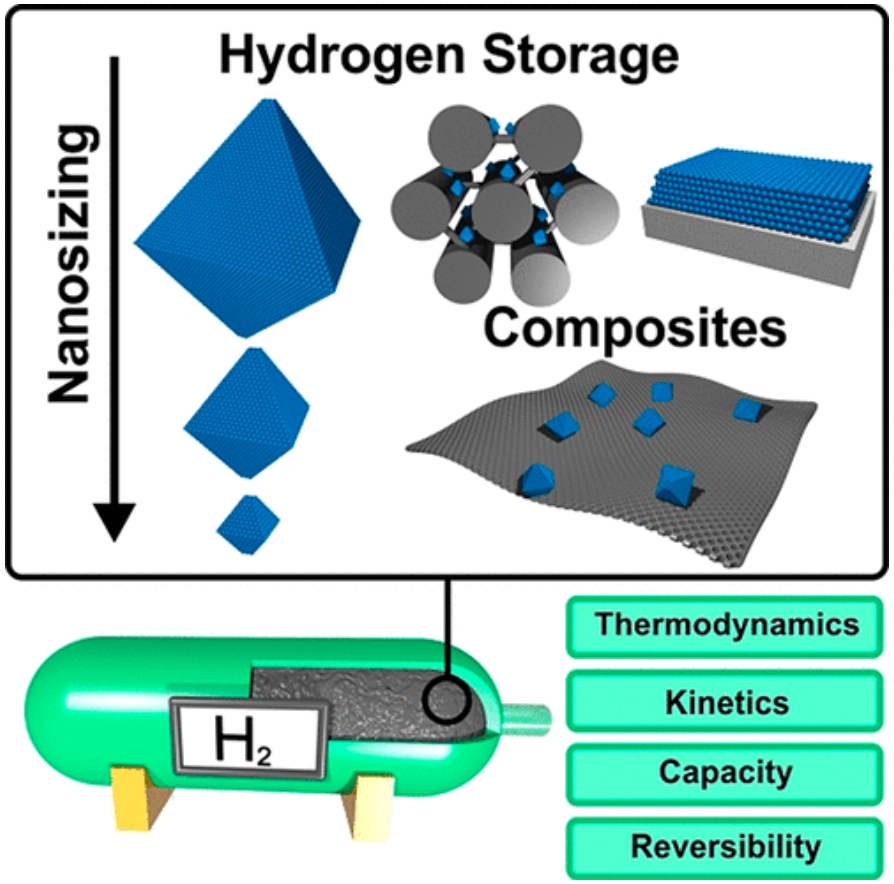


Spotlight Projects

Metal Hydride Composite Hydrogen Storage for Heavy Duty Truck Development

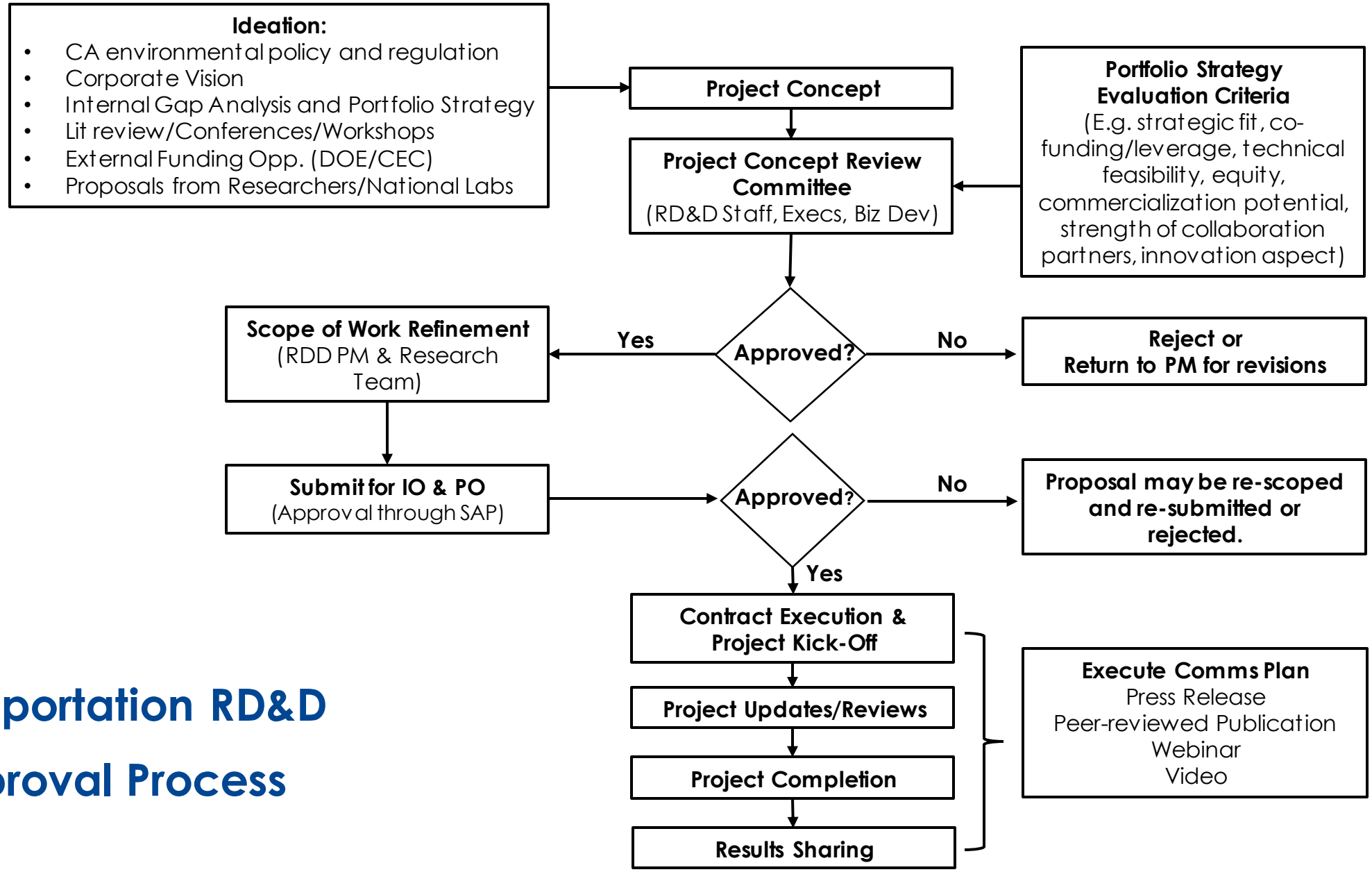
Total Project Cost	$375,000
Start → Finish	11/30/2020 - 06/30/2022
Participants	Sandia National Laboratory

The project aims to research metal hydride composites as a materials-based storage medium to replace high-pressure hydrogen gas storage on heavy-duty fuel cell electric trucks. The thermodynamic and kinetic properties of metal hydrides allow them to fully regenerate following H2 desorption at pressures much lower than 700 bar. Using lower pressure hydrogen could translate into more efficient storage tank designs that weigh and cost less than current high-pressure steel hydrogen storage tanks. Low pressure hydrogen for vehicles can also increase reliability and reduce compression costs at refueling stations by utilizing lower pressure compressors.



Clean Transportation RD&D

Project Approval Process



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Sub-Programs

Clean Transportation

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

Off-Road
Background

Purpose

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.

> "Under current regulations, off-road diesel engines are expected to contribute 95 tons per day (tpd) oxides of nitrogen, or NO_X, and 3.1 tpd of PM to the California emissions inventory in 2030, making off-road diesel the single largest source of mobile emissions in California."
>
> California Air Resources Board

California Air Resources Board

Off-Road
Research

- Research how utilizing hydrogen as fuel for rail, marine, construction, and aviation will help reduce emissions
- Demonstrate new technology to help reduce emissions that meet or exceed regulatory requirements

Technical Targets

- Zero emission technologies for rail, marine, aviation
- Near-zero emission and zero emission construction equipment

Off-Road
Benefits

GHG Benefit

RNG and hydrogen fuel reduce greenhouse gases compared to diesel.

Emissions Benefit

Near-Zero emit 90% and more lower NOx emissions then current diesel engines while zero emissions emit nothing.

Cost-Savings Benefit

Zero-Emission vehicles can benefit from incentives such as the Low Carbon Fuel Standard.

Reliability

Zero-Emission vehicles require less maintenance than their gasoline and diesel counterparts.

Safety

High Pressure and Hydrogen storage tanks are subject to some of the highest safety requirements and to a thorough certification process.

Operational Efficiency

Zero-emission vehicles require less maintenance and can refuel in the same amount of time as their diesel counterparts.

Off-Road
Key Considerations

Policy Alignment

- EO N-79-20
  - 100% zero-emission off-road vehicles and equipment by 2035 where feasible
- CARB Clean Fleets Rule
  - Transition of California to zero-emission where feasible
- CARB At-Berth regulations will deliver a 90 percent reduction in pollution and result in a 55 percent reduction in potential cancer risk for communities near ports

Equity

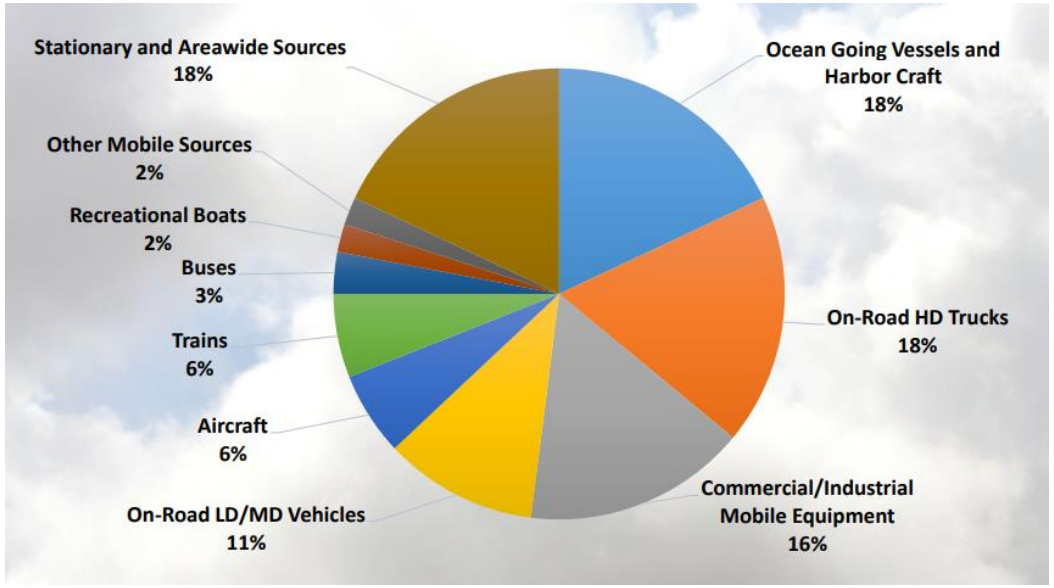
- Disadvantaged communities (DACs) and people of color are disproportionately affected by both mobile and stationary source (MSS) pollution
- MSS reductions will highly benefit DACs
- Seeks rapid transition to zero-emission technology in and near DACs
- Complements AB 617 strategies & consistent with CARB's equity goals

California Air Resources Board "2020 Mobile Source Strategy"

On-Road
Background

Purpose

Targets zero emission technology for medium- and heavy-duty on-road vehicles.



SCAQMD Clean Fuels Advisory, 02/21

- NOx forms ozone & contributes to PM2.5
- Over 80% of the basin's NOx emissions from mobile sources

"Emissions from on-road heavy-duty vehicles are major contributors to poor air quality in California. In particular, diesel vehicles produce emissions in amounts highly disproportionate to the total population of these vehicles."

CARB – On-Road Heavy-Duty Vehicle Program

On-Road Research

- Research in advanced hydrogen fuel cell electric vehicles (FCEV) and zero emission technologies for medium- and heavy-duty freight and people transportation
- Demonstrate zero emission vehicles to help improve and assist in the adoption of the technologies

Technical Targets

- Zero emission tailpipe vehicles
- 1.2 Million Mile Vehicle Life
- 750+ Mile Range for Heavy-Duty
- 30,000 Fuel Cell System Life
- 72% Fuel Cell Efficiency
- 12.4 Mile/Kg Fuel Economy

U.S. Department of Energy

On-Road Benefits

GHG Benefit

Renewable natural gas and hydrogen fuel reduce greenhouse gases compared to diesel.

Emissions Benefit

Zero emission vehicle do not emit NOx or PM compared to their gasoline and diesel counterparts.

Cost-Savings Benefit

Zero-Emission vehicles can benefit from incentives such as the Low Carbon Fuel Standard.

Reliability

Zero-Emission vehicles require less maintenance than current diesel vehicles.

Safety

High Pressure storage tanks are subject to some of the highest safety requirements and to a thorough certification process.

Operational Efficiency

Hydrogen fueling is no more complicated or time-consuming than filling a standard car with gas.

On-Road
Key Considerations

Policy Alignment

- EO B-48-18
  - 5 million ZEVS by 2030
  - 200 hydrogen refueling stations by 2025
- EO N-79-20 (Eliminate new ICE vehicles by 2035)
  - 100% light-duty vehicles and drayage trucks sold will be zero emission by 2035
  - 100% medium- and heavy-duty vehicles sold and operated are zero-emission by 2045
- CARB Clean Truck Rule
  - 100% ZEV where feasible for drayage, public fleets, last-mile delivery by 2045
- CARB Clean Fleet Rule
  - 100% zero-emission trucks and buses where feasible by 2045

Equity

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

Refueling Stations
Background

Purpose

Technologies and systems that support refueling for alternative fuels, including CNG, RNG, and hydrogen.

> **"Delivery technology for hydrogen infrastructure is currently available commercially, and several U.S. companies deliver bulk hydrogen today. Some of the infrastructure is already in place because hydrogen has long been used in industrial applications, but it's not sufficient to support widespread consumer use of hydrogen as an energy carrier."**
> – DOE https://www.energy.gov/eere/fuelcells/hydrogen-delivery

National Renewable Energy Lab

Refueling Stations
Research

- Research of advanced full fill technologies to resolve issues in CNG and hydrogen fuel cell vehicles.
- Optimization of hydrogen refueling stations looking at improving hydrogen compressors, increasing the efficiency of overall refueling stations, and alternative technologies.

Technical Targets for CNG

- Full fill during "fast-fill" process

Technical Targets for Hydrogen

- $4/GGE Dispensed Hydrogen at Pump
- 3 – 5 Minute Hydrogen System Fill Time
- 10 kg/min Hydrogen Fill Rate
- 5,000 Hydrogen Storage System Cycle Life
- $8/kg Hydrogen Storage System Cost

U.S. Department of Energy

Refueling Stations
Benefits

Cost-Savings Benefit

Optimizing refueling stations can decrease needed power for compressors and other equipment to reduce costs.

Reliability

Help reduce our dependence on foreign oil since it is domestically produced.

Operational Efficiency

Optimizing refueling stations can decrease refueling times and can supplement fueling for on-road vehicles and nearby buildings through distributed energy resources.

Emissions Benefit

Optimizing refueling stations can decrease emissions from additional devices that are essential to deliver the hydrogen to customers.

GHG Benefit

Renewable natural gas and hydrogen fuel reduce greenhouse gases given their lower carbon intensity relative to diesel.

Safety

Technologies to reduce and mitigate potential risks in near-zero and zero emission infrastructure to be as safe as gasoline stations.

Refueling Stations
Key Considerations

Policy Alignment

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

Equity

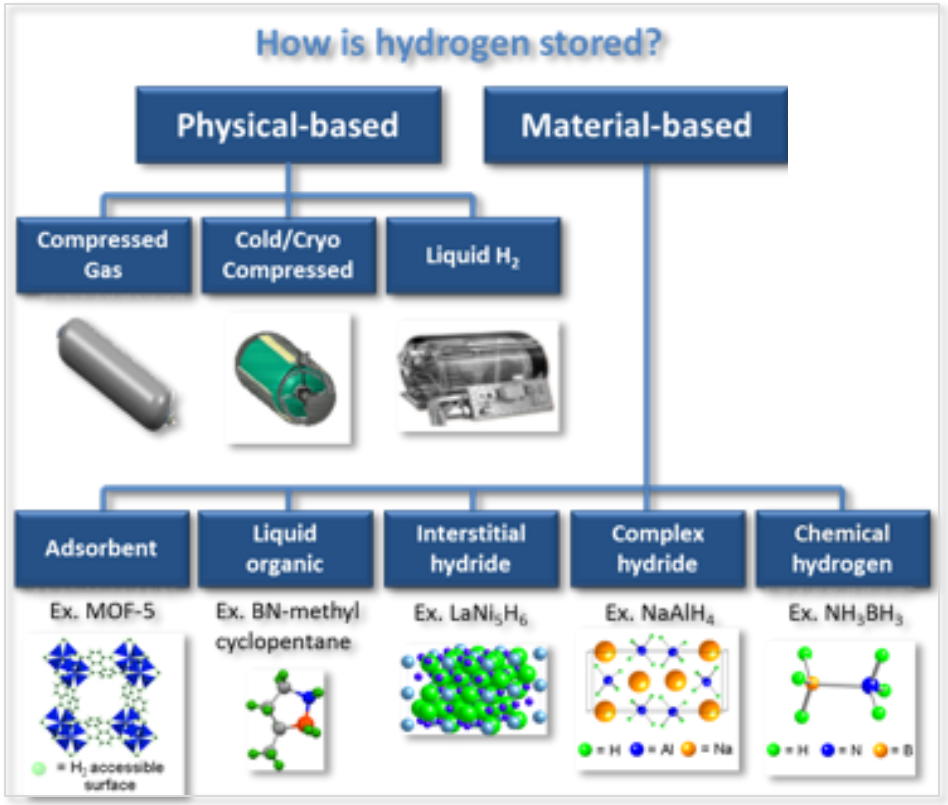
To support the growth of hydrogen mobility, infrastructure is critical to ensuring the customer has a safe, convenient, reliable, high quality, low cost fueling experience. "Innovations in California policy, including infrastructure capacity crediting in the Low Carbon Fuels Standard and a multi-year structure in grant funding, enable us to deliver this station development program and decarbonize hydrogen to near-zero or below,"

- "SHELL TO EXPAND CALIFORNIA HYDROGEN REFUELLING INFRASTRUCTURE", SHELL

Onboard Storage
Background

Purpose

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



U.S. Department of Energy

> "Hydrogen storage is a key enabling technology for the advancement of hydrogen and fuel cell technologies in applications including stationary power, portable power, and transportation. Hydrogen has the highest energy per mass of any fuel; however, its low ambient temperature density results in a low energy per unit volume, therefore requiring the development of advanced storage methods that have potential for higher energy density."
> - DOE, https://www.energy.gov/eere/fuelcells/hydrogen-storage

Onboard Storage
Research

- Researching improvements in capacity, conformability, safety, and cost of on-board storage of gaseous fuels through conformable and low-pressure tanks
- Research fueling protocols and applications to allow faster and fuller fills for renewable natural gas and renewable hydrogen

Technical Targets for CNG

- Low Pressure and Full Fill Technology

Technical Targets for Hydrogen

- 5,000 Storage System Cycle Life
- 11,000 Pressurized Storage System Cycle Life
- $8/kg Hydrogen Storage System Cost
- 700 bar and 350 bar Hydrogen Storage Tanks

U.S. Department of Energy

Onboard Storage
Benefits

Cost-Savings Benefit

Low pressure storage tanks require less compression and power needed to operate and advanced onboard tanks help decrease costs.

Safety

Advanced materials can help store fuel at lower pressures and meet highest safety requirements of high-pressure storage vessels.

Operational Efficiency

Higher absorption and desorption materials can help reduce refueling times and fuller fills to maximize range and efficiency.

Reliability

Low pressure and advanced onboard storage tanks can provide greater cycle life and reduce required load on infrastructure

GHG Benefit

Renewable natural gas and hydrogen fuel reduce greenhouse gases given their lower carbon intensity relative to diesel.

Emissions Benefit

Low pressure storage tanks require less compression and power needed to operate.

Onboard Storage
Key Considerations

Policy Alignment

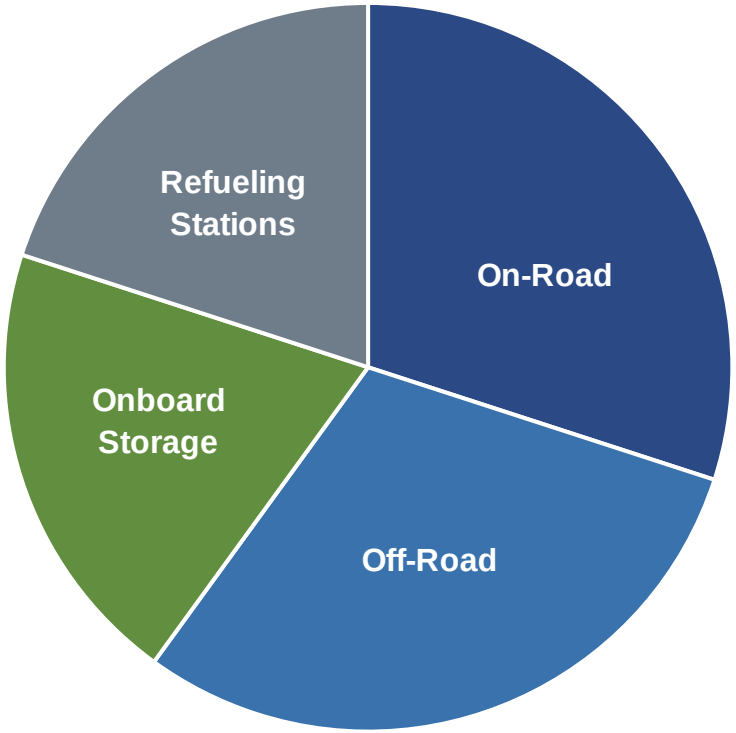
- EO B-48-18
  - 5 million ZEVS by 2030
  - 200 hydrogen refueling stations by 2025
- EO N-79-20 (Eliminate new ICE vehicles by 2035)
  - 100% light-duty vehicles and drayage trucks sold will be zero emission by 2035
  - 100% medium- and heavy-duty vehicles sold and operated are zero-emission by 2045

Equity

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

-Ballard Fuel Cell Systems

2022 Proposed Funding Allocation



Sub-Program	Allocation
On-Road	30%
Off-Road	30%
Refueling Stations	20%
Onboard Storage	20%
Total	**$2,078,244**

Specific Areas We Would Like Feedback

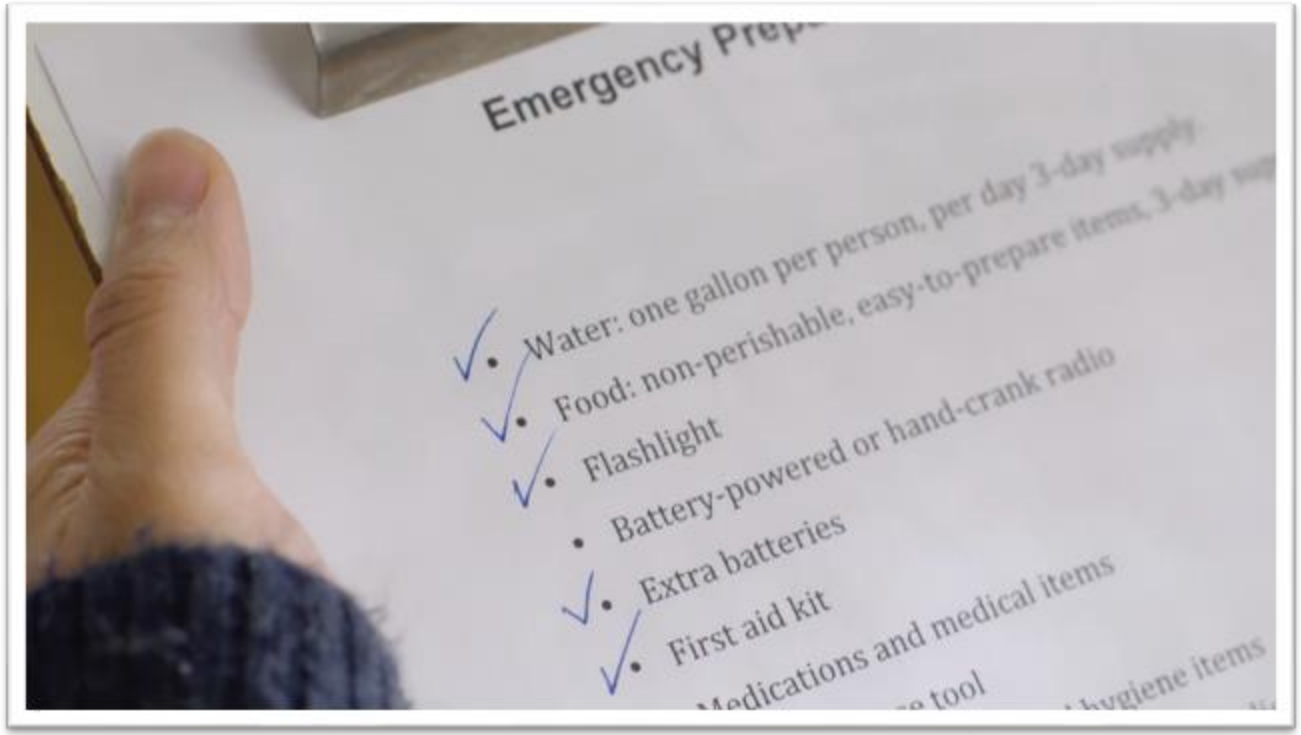
1. Are there technologies or research areas currently missing?
2. What areas can renewable natural gas and renewable hydrogen transportation technologies make the biggest impact?
3. What are suitable technical targets/technology for off-road (marine, rail, aviation, construction)?
4. What areas of research do we need to focus on to meet the California's transportation decarbonization goals?

Safety Moment #3

To learn more about safety, visit:
https://www.socalgas.com/stay-safe/safety-and-prevention

Emergency Preparedness

- Informational Video (30 sec)



https://youtu.be/lrIldXI4K8A

VII. Clean Generation

- Overview & Goals
- Spotlight Projects
- Sub-Programs Overview
- Project Approval Process
- Distributed Generation
- Integration & Controls
- 2022 Proposed Funding Allocation
- Specific Areas We Would Like Feedback

SoCalGas

Overview & Goals

The Clean Generation RD&D Program focuses on supporting the development and demonstration of high-efficiency, low-emissions power generation technologies for the commercial, industrial, and residential market segments.

Goals

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

Spotlight Projects

Mainspring Energy Ultra-Low NOx Linear Power Generator Demonstration

Total Project Cost	$2,381,725
Start → Finish	5/1/2018 - 12/31/2021
Participants	Mainspring Energy, CEC

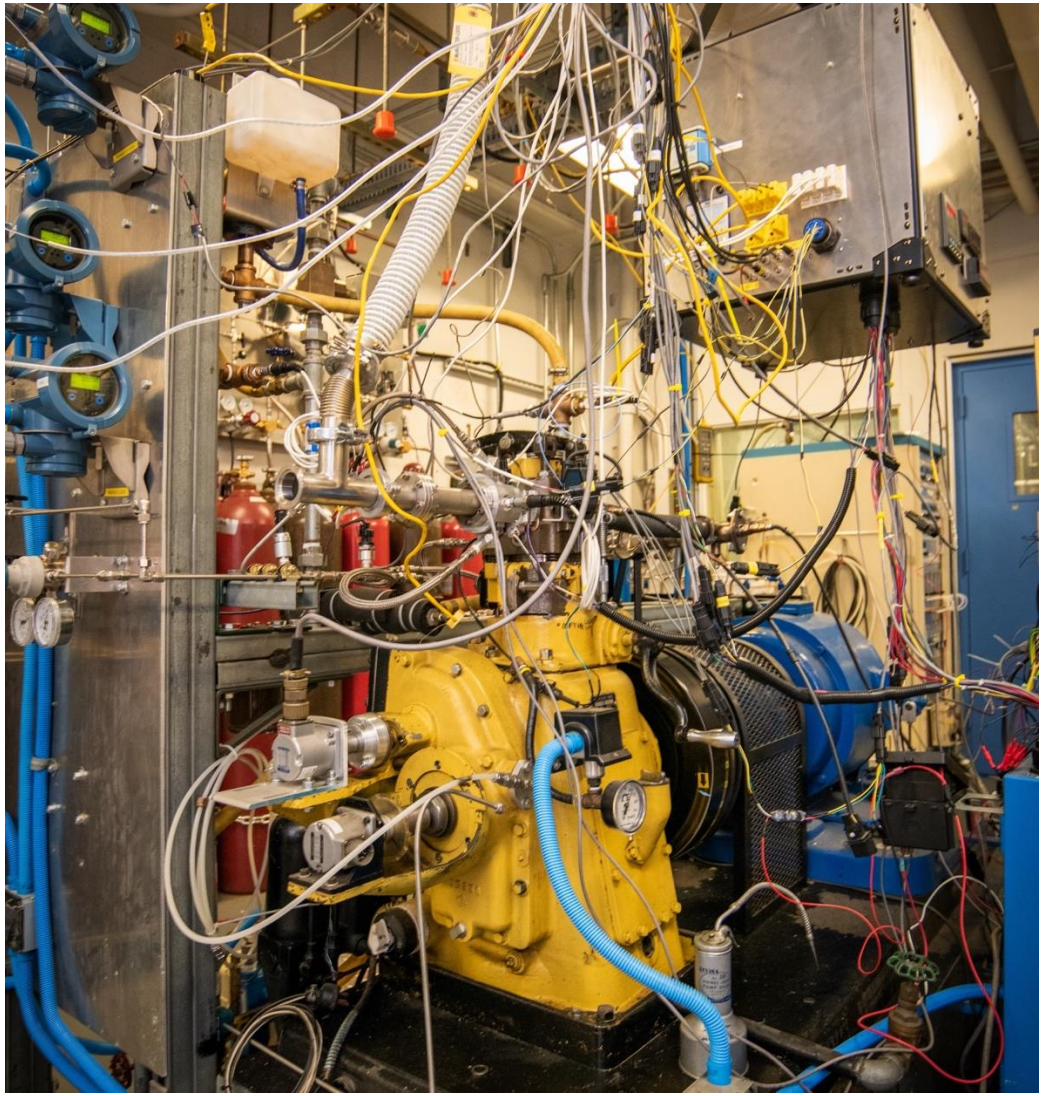
The goal of this project is to demonstrate Mainspring Energy's Linear Power Generator at a grocery store in Colton, CA. The demonstration will showcase the technology's ability to provide high efficiency, low emissions power, at a low cost.

Spotlight Projects

Noble Thermodynamic Systems Argon Power Cycle CHP Development

Total Project Cost	$5,279,034
Start → Finish	8/14/2020 - 9/30/2023
Participants	Noble Thermodynamic Systems, DOE

The goal of this project is to demonstrate the ability of the novel Argon Power Cycle to provide an 18% increase in efficiency, while eliminating emissions, in an internal combustion engine.



Spotlight Projects

Blue Frontier Fuel Cell Powered HVAC Development

Total Project Cost	$540,000
Start → Finish	11/1/2019 – 6/30/2021
Participants	Blue Frontier, NREL

The goal of this project is to investigate the performance of Blue Frontier's Enhanced Liquid Desiccant Energy Storage Air Conditioning, which can be integrated with a fuel cell micro-CHP unit to store thermal energy which is used to provide dispatchable cooling.

Spotlight Projects

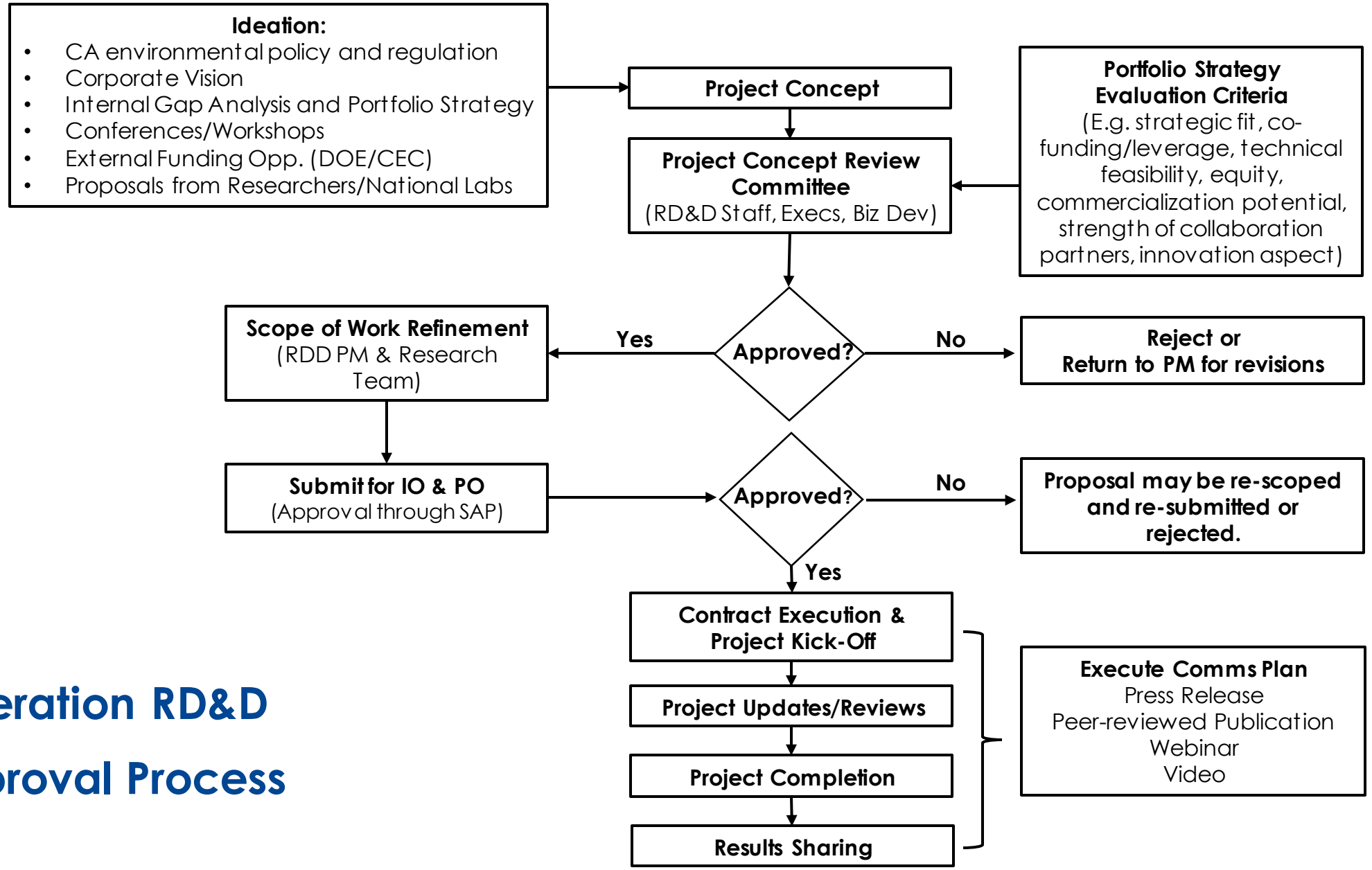
GTI Upstart Power Residential SOFC Laboratory Evaluation

Total Project Cost	$190,000
Start → Finish	8/17/2020 – 12/31/2021
Participants	GTI, Upstart Power

The goal of this project is to evaluate the performance of Upstart Power's Upgen 10 SOFC system operating on natural gas. Upstart's system is designed to provide rapid cycling capabilities and be integrated with solar and battery storage.

Clean Generation RD&D

Project Approval Process



Sub-Programs

Clean Generation

- Distributed Generation
- Integration & Controls

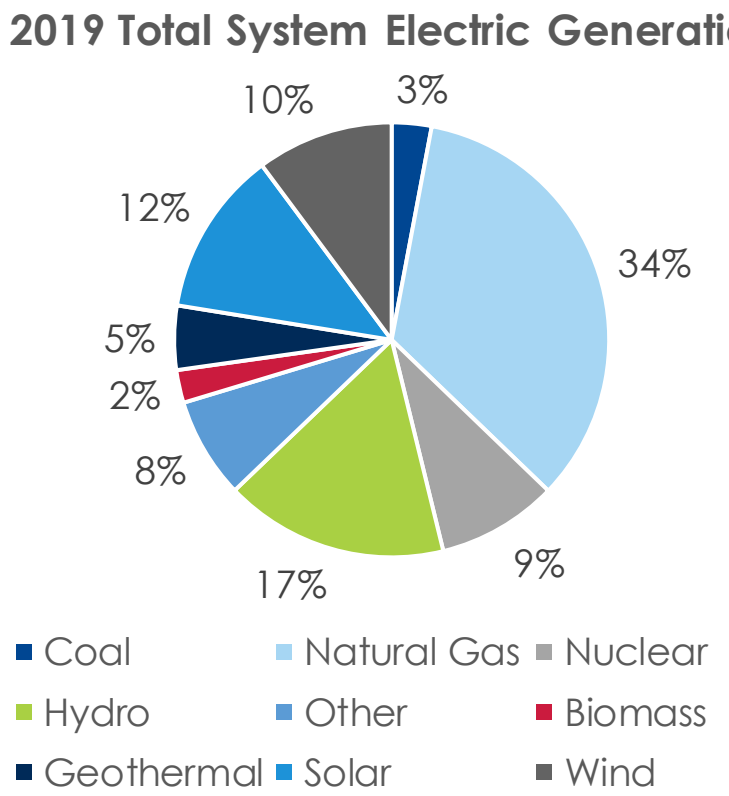
Distributed Generation

Background

Purpose

Develop and enhance low-emission distributed generation technologies.

> **"Economics and resilience are expected to be the primary drivers for CHP adoption in California, but there will also be societal benefits from CHP installations as higher energy efficiencies and reduced greenhouse gas emissions compared to separate heat and utility power."**
>
> - CEC-500-2019-030



California Energy Commission

Distributed Generation
Research

- Developing, testing, and demonstrating residential/small commercial fuel cell systems.
- Developing, testing, and demonstrating hydrogen blending in existing DG technologies to determine performance characteristics and emissions impacts.
- Developing, testing, and demonstrating new, low-emissions backup power and CHP technologies.

Technical Targets

January 1, 2007 Emission Standards (lb/MW-hr)

Pollutant	Emission Standard
Oxides of Nitrogen (NO_x)	0.07
Carbon Monoxide (CO)	0.10
Volatile Organic Compounds (VOCs)	0.02
Particulate Matter (PM)	An emission limit corresponding to natural gas with fuel sulfur content of no more than 1 grain/100 scf

California Air Resources Board

Distributed Generation

Benefits

GHG Benefit

Improving the efficiency and increasing hydrogen tolerance of DG technologies lowers GHG emissions.

Emissions Benefit

This sub-program focusses on developing technologies that meet CARB-DG certification standards.

Cost-Savings Benefit

By improving the efficiency of DG technologies, customer energy costs are reduced.

Reliability

Distributed generation has the ability to provide highly reliable and resilient electricity to customers.

Operational Efficiency

By improving the efficiency of DG technologies, our customers' operational efficiencies are improved.

Distributed Generation

Key Considerations

Policy Alignment

This sub-program strives to reduce emissions from power generation technologies.

- CPUC R.19-09-009 (Microgrids and Resiliency proceeding)
- AB 3232 (Building decarbonization)
- SB 32 (Reduce CO2 emissions)
- Clean Air Act (Air quality standards for NOx and PM)
- SB 100 (Zero-carbon electricity by 2045)
- EO B-55-18 (Carbon neutral economy by 2045)
- Clean Air Act (Air quality standards for NOx and PM)
- SB 1298 (Distributed generation regulation)
- Self-Generation Incentive Program (SGIP)

Equity

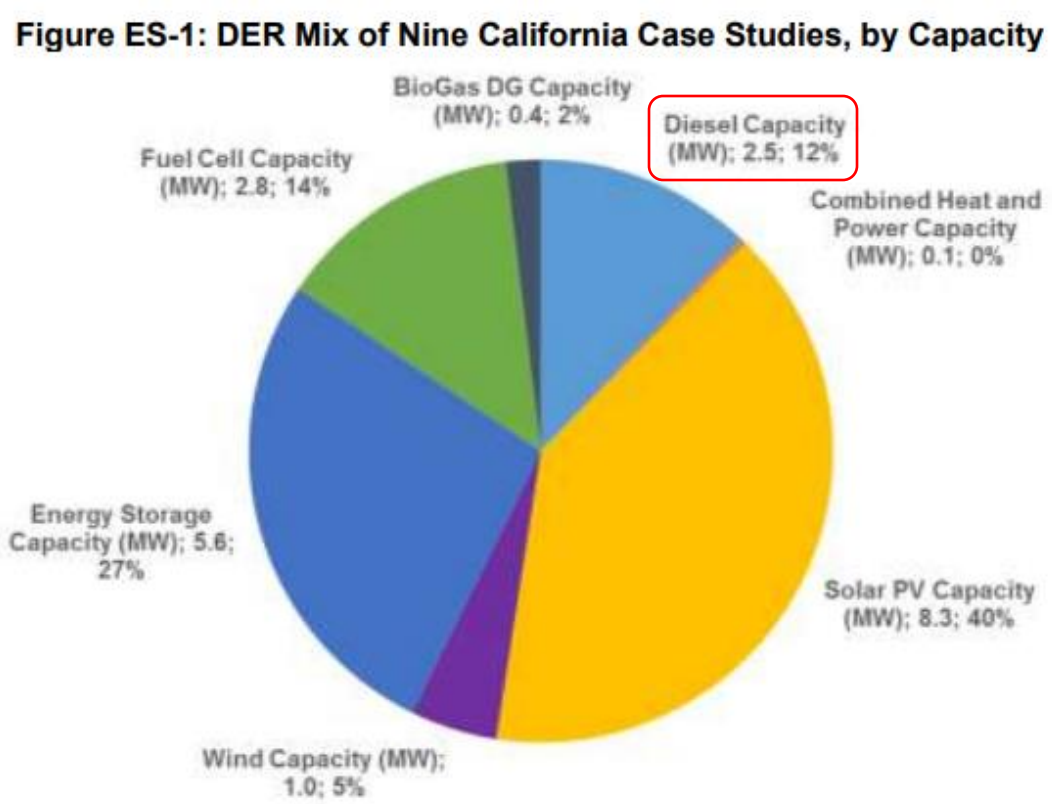
Low emissions distributed generation technologies have the ability to provide energy resilience to vulnerable populations (e.g. medical baseline customers). Deployment of diesel-replacing distributed generation within industrial areas adjacent to lower-income communities improves air quality.

Integration & Controls
Background

Purpose

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

> **"If you've seen one microgrid, you've seen one microgrid."**
> - Unknown



California Energy Commission

Integration & Controls
Research

- Identify installation challenges and technical barriers that lead to the need for custom microgrid solutions.
- Develop and test control systems to simplify and/or optimize the integration of gas fueled DG with solar + battery systems.
- Develop and test technologies that increase the value of CHP systems.

Technical Targets

- Ability to seamlessly integrate gas DG
- Ability to balance multiple generation sources and loads
- Power factor correction
- Optimization of complete energy system to meet customer needs
- Cost competitive with non-integrated baseline solutions

Integration & Controls

Benefits

GHG Benefit

Optimizing the integration of gas fueled DG with existing customer power systems and heating technologies has the ability to greatly reduce CO2 emissions.

Emissions Benefit

Integrating low-emissions DG, such as fuel cells, with solar + storage and heat driven appliances has the ability to greatly reduce criteria pollutants (NOx).

Cost-Savings Benefit

Developing "off-the-shelf" solutions for DG integration has the ability to reduce installation costs, while the development of improved control systems can reduce customer energy costs.

Reliability

Ensuring customer energy systems are integrated and optimized improves power reliability and resilience.

Safety

When power reliability and resilience is increased, customer safety is improved due to the ability to keep critical equipment (e.g. HVAC, medical equipment, etc) operating during grid outages.

Operational Efficiency

Optimizing the integration of gas fueled DG with existing customer power systems and heating technologies ultimately improves the overall energy efficiency for a customer.

Integration & Controls

Key Considerations

Policy Alignment

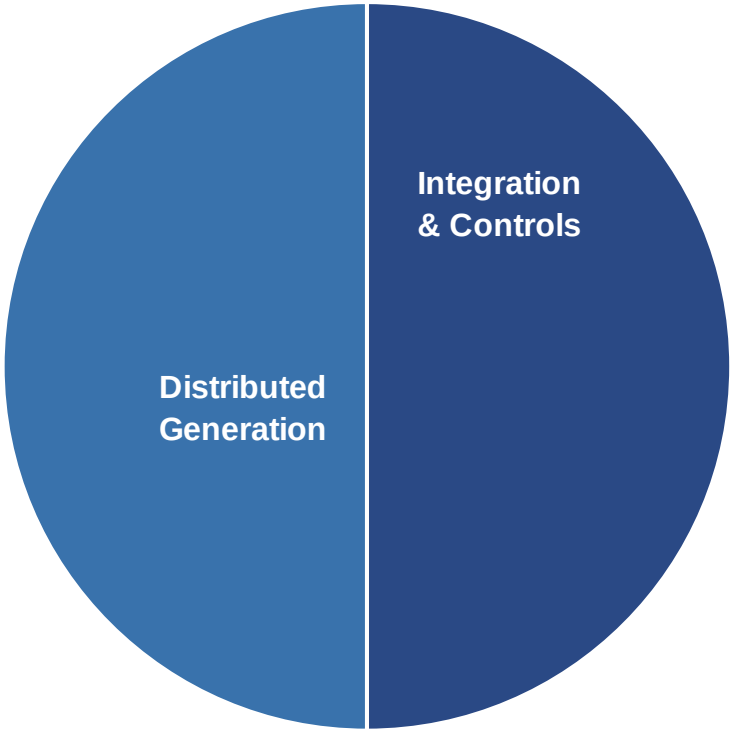
Optimizing the integration of clean gas-fueled DG with customer's existing energy systems has the ability to provide significant emissions reductions.

- SB 1339 (Microgrids for increased electricity reliability)
- CPUC R.19-09-009 (Microgrids and Resiliency proceeding)
- AB 3232 (Building decarbonization)
- SB 100 (GHG emissions)
- Clean Air Act (Air quality standards for NOx and PM)
- EO B-55-18 (Carbon neutral economy by 2045)
- CA Title 24 (Buildings Energy Efficiency)

Equity

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

2022 Proposed Funding Allocation



Sub-Program	Allocation
Integration & Controls	50%
Distributed Generation	50%
Total	**$1,632,906**

Specific Areas We Would Like Feedback

1. What size distributed generation technologies should we focus on to have the biggest impact?
2. How would you prioritize developing new DG technologies (fuel cells and novel low emissions systems) vs improving the performance of existing DG technologies (engines/turbines)?
3. How should resilience be valued (other than production losses)?
4. Are there specific DG or microgrid technologies that you are aware of that we should consider looking at?
5. Are there any specific technical targets around Integration & Controls we should consider?

LUNCH BREAK

The next session will start at 1:00pm

- ✓ Please enjoy your lunch, take some time to move around, stretch, and rest your eyes.

Customer End-Use Applications

- Overview & Goals
- Spotlight Projects
- Sub-Programs Overview
- Project Approval Process
- Commercial Food Service
- Residential Applications
- Commercial Applications
- Industrial Process Heat
- Advanced Innovation
- 2022 Proposed Funding Allocation
- Specific Areas We Would Like Feedback

SoCalGas

Overview & Goals

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

Goals

- 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

Spotlight Projects

GTI Residential Gas Heat Pump Water Heater Field Demonstration

Total Project Cost	$1,084,230
Start → Finish	2/27/2017 - 10/15/2020
Participants	GTI, CEC, SMTI, Rinnai

This project's focus is on field, laboratory, and market evaluation of a "fourth generation" pre-commercial gas heat pump water heater (GHPWH) to quantify annual energy, cost, and emissions savings. In comparison to conventional water heaters, preliminary results show an energy savings of 54% and GHG emission reduction of 49%.

Spotlight Projects

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

Total Project Cost	$1,129,794
Start → Finish	4/17/2017 - 2/1/2021
Participants	GTI, CEC, SMTI, AO Smith

In this project, a pre-commercial GHP that can simultaneously produce hot water and space cooling for restaurants is being field demonstrated. The GHP is expected to have a heating efficiency of 140% or greater and may yield therm savings of up to 45% in addition to providing 'free cooling'.

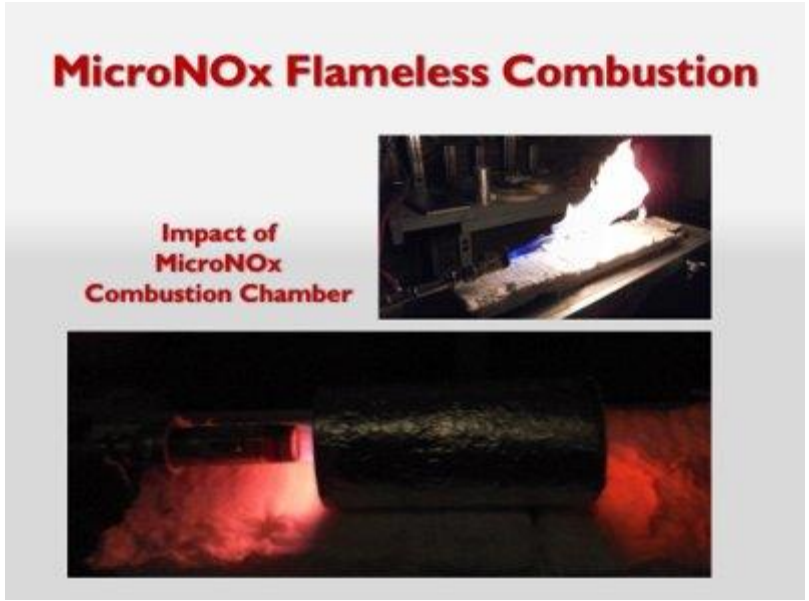
Customer
End-Use

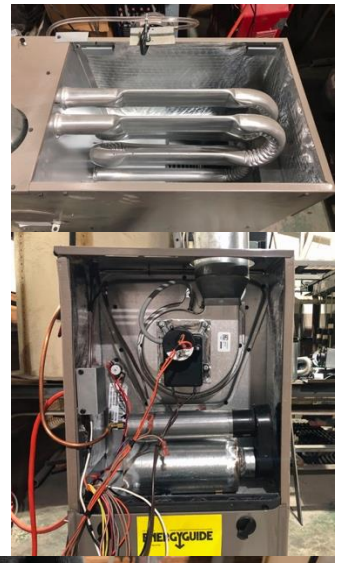
Spotlight Projects

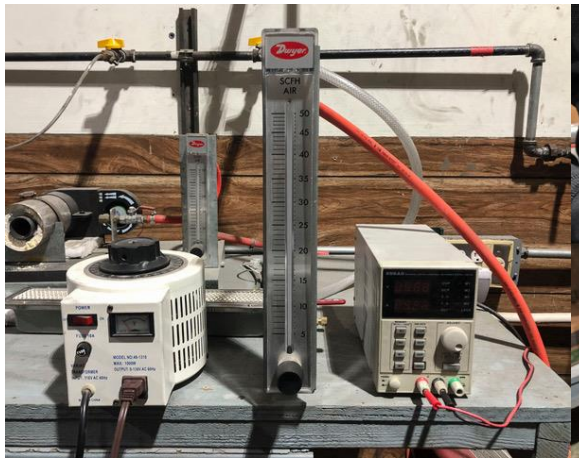
Lantec Ultra Low NOx Forced Air Residential Furnace Development

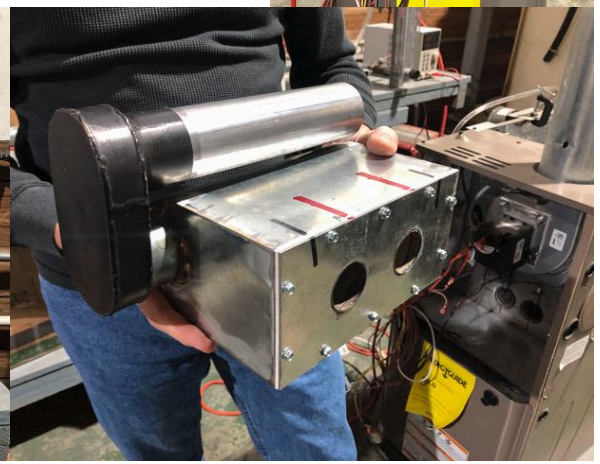
Total Project Cost	$432,500
Start → Finish	5/01/2019 - 1/31/2022
Participants	Lantec, SCAQMD

The goal of this project is to design and develop residential condensing and non-condensing forced air furnaces utilizing Lantec Products' novel MicroNOx combustion technology. Successful completion of the project will result in a cost-effective, ultra-low NOx forced air furnace design with a NOx emissions target of 7 ng/J, which is 50% below Rule 1111 NOx emissions standards of 14 ng/J.







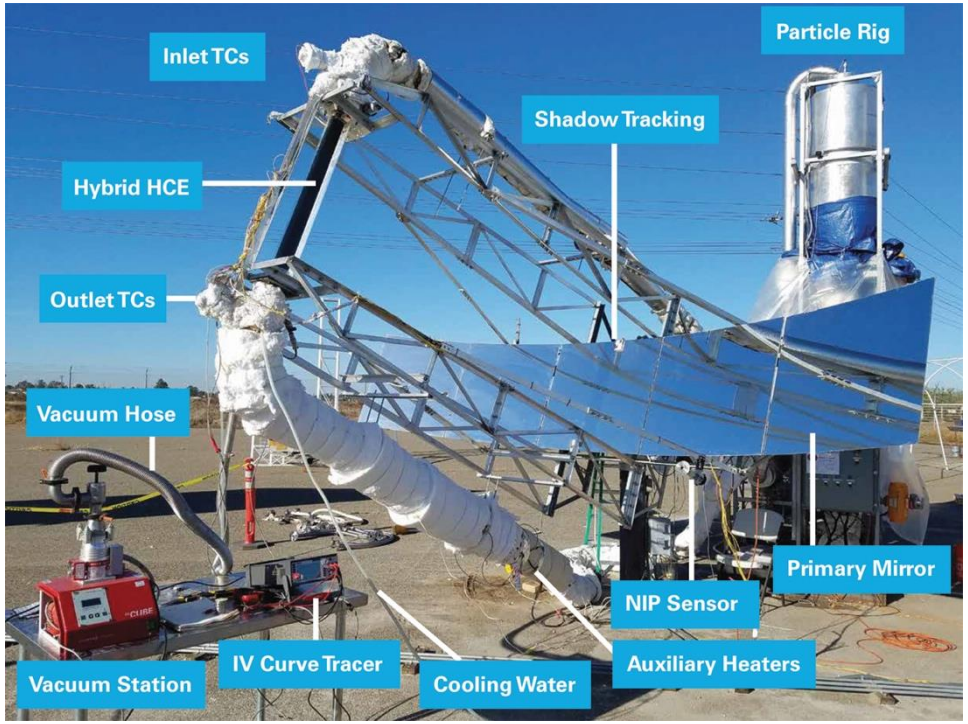


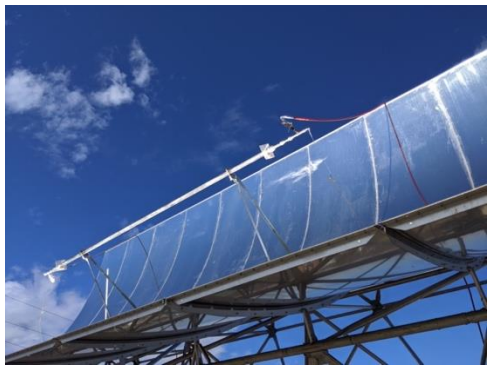
Spotlight Projects

GTI Solar Thermal and Particle Fluid Demonstration

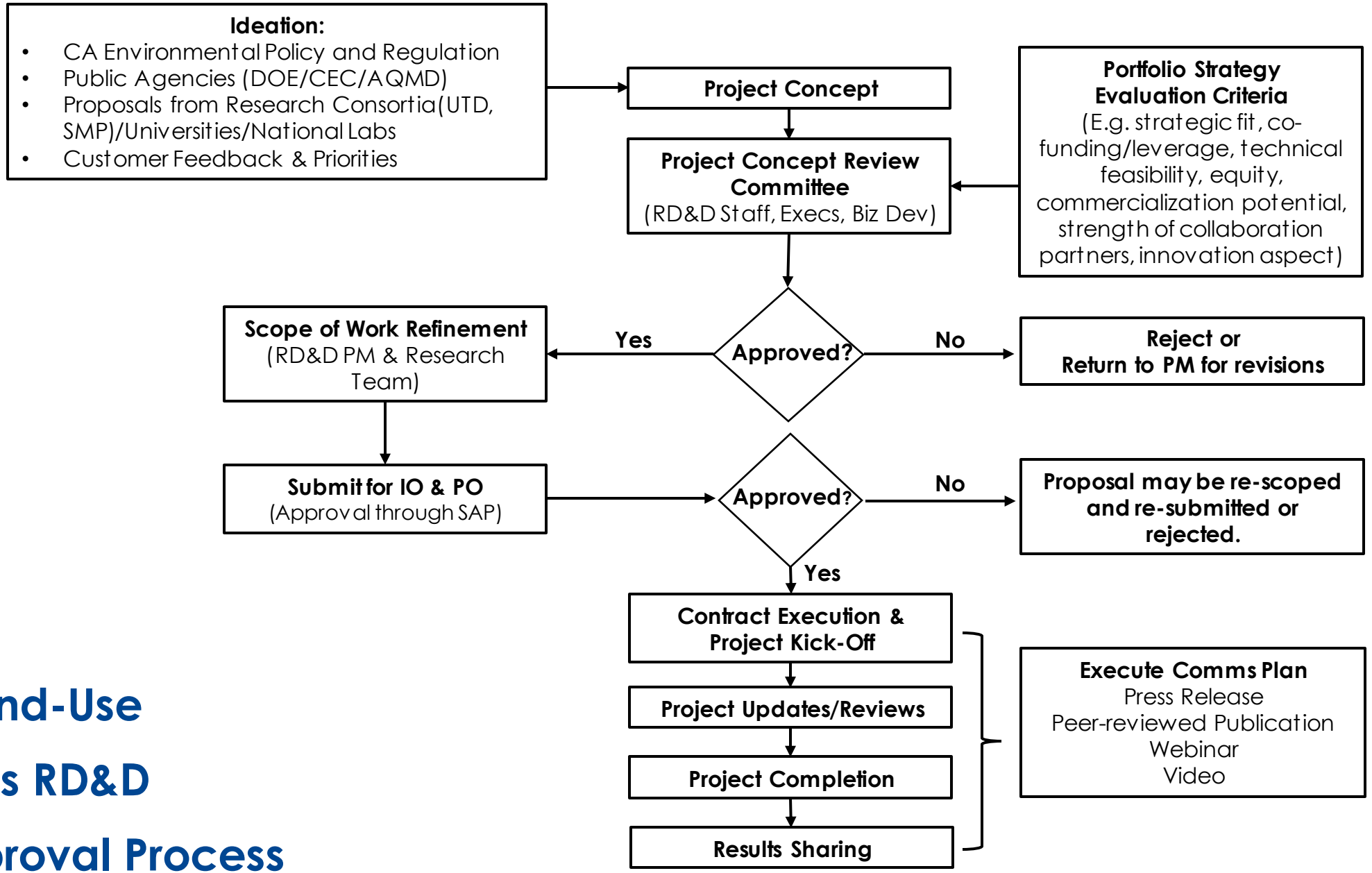
Total Project Cost	$3,260,000
Start → Finish	10/01/2018 - 04/01/2022
Participants	GTI, ARPA-E, CEC, UC Merced

The goal of the project is to demonstrate an advanced solar thermal collector capable of +600°C and a novel particle thermal storage medium for process heating at an industrial facility in California. The demonstration will verify the performance, energy savings, and emissions benefits of the technology. The technology is expected to deliver over 40% of the collected solar energy to the process application.





Customer End-Use Applications RD&D Project Approval Process



Sub-Programs

Customer End-Use Applications

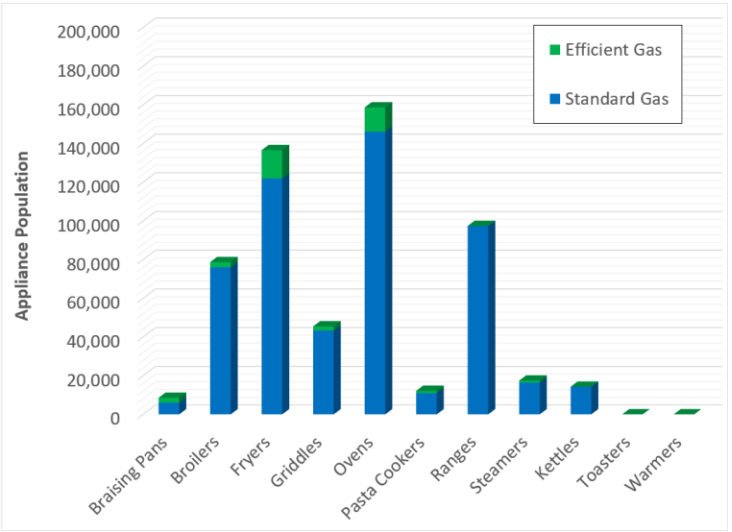
- Commercial Food Service
- Residential Appliances
- Commercial Applications
- Industrial Process Heat
- Advanced Innovation

Commercial Food Service
Background

Purpose

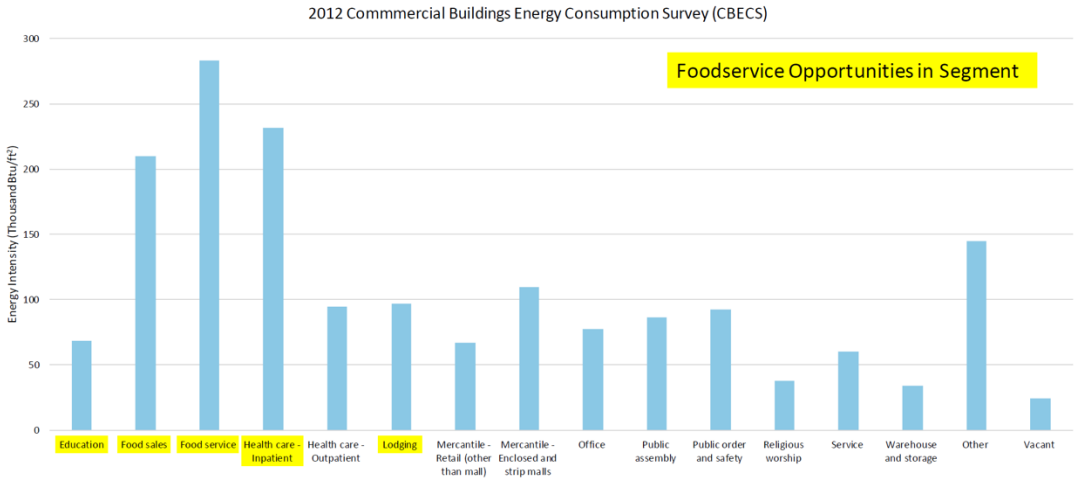
Develop and enhance technologies and advancements related to commercial food service. Includes restaurants, catering services, and institutional kitchens that primarily rely on fuel supplied by SoCalGas.

CA Appliance Population vs. Type



Source: GTI CFS Working Group

Relative scale of Energy Intensity in All U.S. Building Sectors



Source: EIA – 2012 Commercial Buildings Energy Consumption Survey (https://www.eia.gov/consumption/commercial/)

"Food service is one of the largest single commercial end-uses. Pretty much everyone is touched everyday by Commercial Food Service.
It is also a very hard-to-reach customer base."

- Frontier Energy

Customer
End-Use

Commercial Food Service

Research

- Hydrogen and RNG integration: safe, efficient, and effective technologies that will enable the use of hydrogen and RNG for CFS appliances.
- Develop next generation burners, gas heat pump water heaters, and kitchen ventilation systems.
- Increase adoption of new high efficiency equipment through demonstrations and supporting restaurant operators with education (e.g. webinar, conferences, journal publications).

Technical Targets

Appliance Efficiency Table	Standard (%)	Medium (%)	High (%)
Fryer	35	50	57
Griddle	30	38	46
Combi	35	44	56
Steamer	15	38	45
Convection Oven	30	46	52

Source: Frontier Energy Food Service Technology Center (FishNick)

Commercial Food Service

Benefits

Customer
End-Use

GHG Benefit

Projects in this sub-program seek to increase energy efficiency and burner performance which provides GHG benefit by reducing emissions from CFS equipment.

Emissions Benefit

The CFS sector is a highly energy intensive sector. Improved burner performance and energy efficiency significantly reduces GHG and NOx emissions.

Cost-Savings Benefit

Increasing energy efficiency and burner performance results in energy cost savings and improved ROI.

Operational Efficiency

Increasing energy efficiency and burner performance also provides improved operational efficiency for customers by reducing cooking time, increasing food output, and reducing fuel cost.

Customer
End-Use

Commercial Food Service

Key Considerations

Policy Alignment

This sub-program supports the following policies:

- AB3232 (Building Decarbonization)
- CA Title 20 (Appliance Energy Efficiency)
- CA Title 24 (Buildings Energy Efficiency)
- AB32 (Reduce CO2 emissions 40% below 1990 levels by 2030)
- EO B-55-18 (Carbon-neutral California economy by 2045)
- 2016 AQMP (Air Quality Management Plan, NOx and PM emissions regulation)
- AB617 (Disadvantaged communities for air quality improvements)

Equity

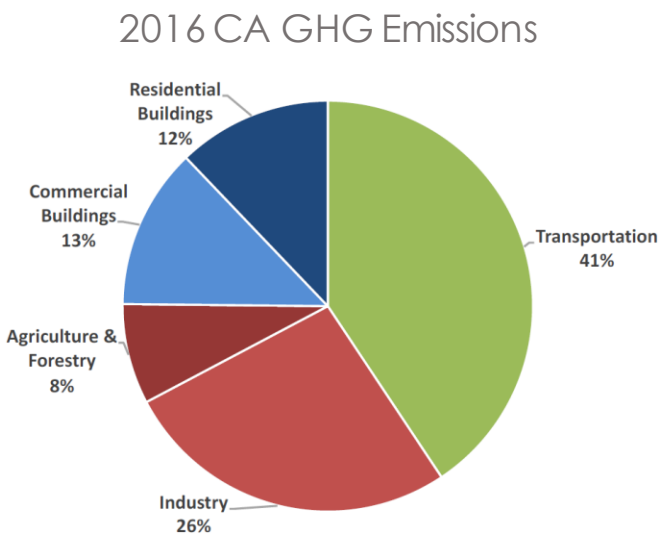
Half of all American adults have worked in the restaurant industry. This sub-program seeks to reduce emissions, improve air quality, and increase profitability for an important sector that employs more minority workers than any other industry.*

*Source: National Restaurant Association

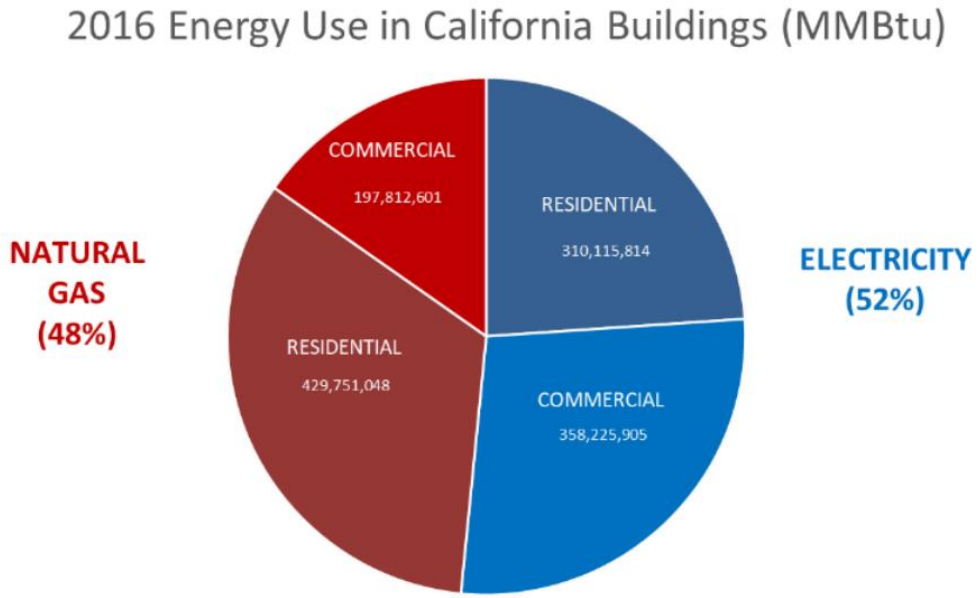
Residential Appliances
Background

Purpose

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



Source: California Air Resources Board - 2018 Edition California Greenhouse Gas Inventory for 2000-2065 — by Sector and Activity

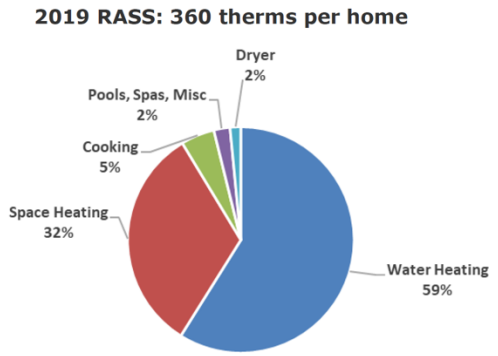


Source: California Energy Commission - CA Building Energy Policy

Residential Appliances
Research

- Hydrogen and RNG integration for residential appliances.
- Develop residential water heating, space heating, and cooking appliances.
  - Energy Efficiency Improvements.
  - Achieve NOx reduction requirements.

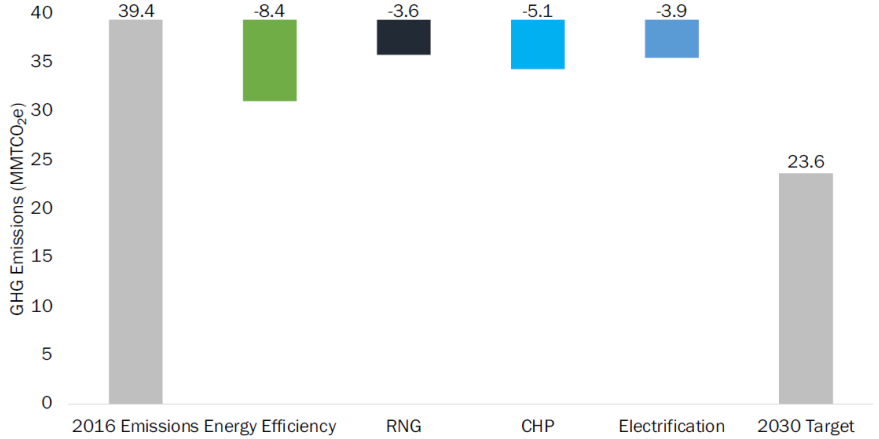
Statewide Gas Consumption



Source: 2019 California Residential Appliance Saturation Survey

Technical Targets

Figure 5-14
Buildings Sector Pathways and 2030 Target ($MMTCO_2e$)



The Buildings sector could meet a 40 percent reduction in emissions by 2030 by pursuing energy efficiency measures and utilizing RNG, CHP, and electrification for various commercial and residential end uses. Source: EFI, 2019.

Source: EFI 2019

Residential Appliances
Benefits

Customer
End-Use

GHG Benefit

Developing advanced appliances that are compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from residential buildings.

Emissions Benefit

Increasing energy efficiency and burner performance for residential appliances provides an environmental benefit by reducing NOx and PM emissions.

Cost Savings Benefit

Increased energy efficiency improves cost savings and ensures that energy is affordable and equitable.

Operational Efficiency

Increasing energy efficiency and burner performance for residential appliances also provides improved operational efficiency for customers by reducing fuel cost associated with space conditions, water heating, and cooking.

Customer
End-Use

Residential Appliances
Key Considerations

Policy Alignment

This sub-program supports the following policies:

- AB3232 (Building Decarbonization)
- CA Title 24 (Buildings Energy Efficiency)
- CA Title 20 (Appliance Energy Efficiency)
- 2016 AQMP (Air Quality Management Plan, NOx and PM emissions regulation)
- AB32 (Reduce CO2 emissions 40% below 1990 levels by 2030)
- EO B-55-18 (Carbon-neutral California economy by 2045)
- AB617 (Disadvantaged communities for air quality improvements)

Equity

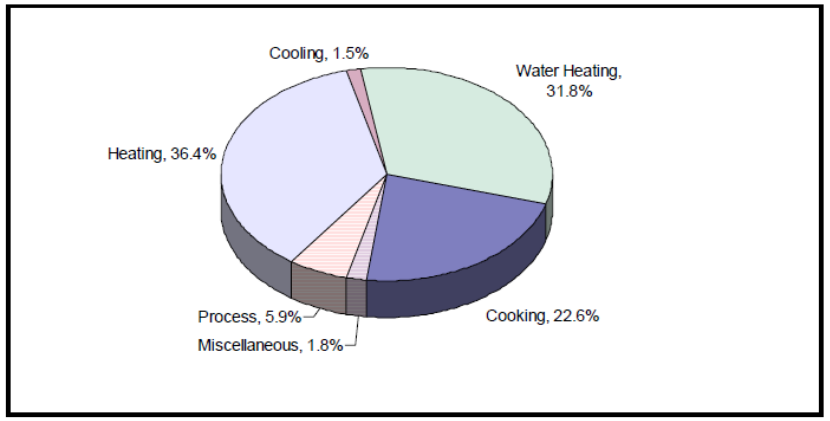
The introduction of hydrogen may have higher upfront costs than conventional fuels. Therefore, high energy efficiency appliances in the residential space will play a greater importance in ensuring that clean energy is affordable and equitable.

Commercial Applications
Background

Purpose

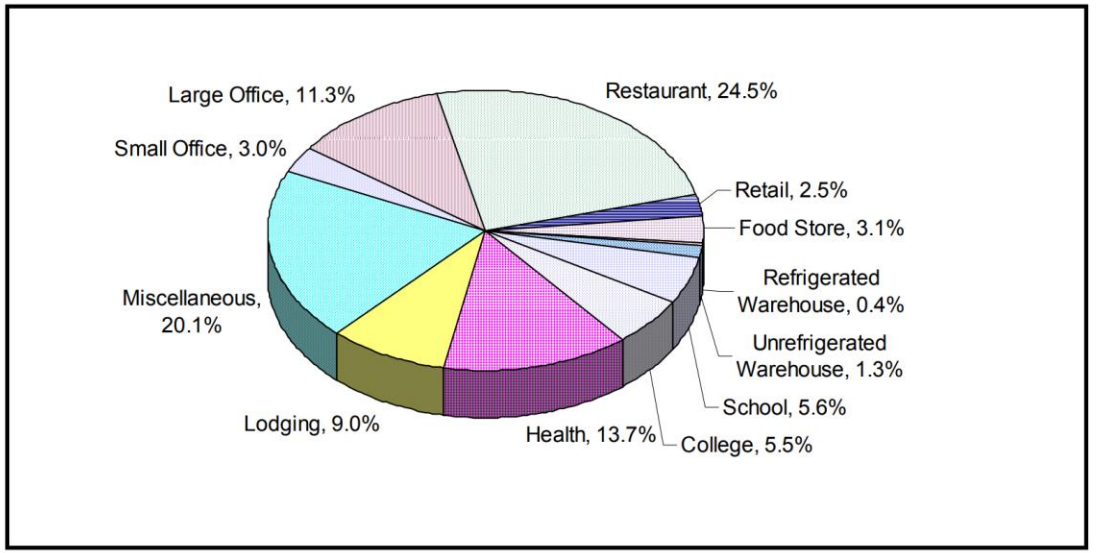
Develop and enhance technologies and advancements related to gas consumption and end-uses in the commercial sector.

Figure E-4: Natural Gas Usage by End Use



Source: 2006 California Commercial End-Use Survey

Figure E-2: Commercial Gas Usage by Building Type



Source: 2006 California Commercial End-Use Survey

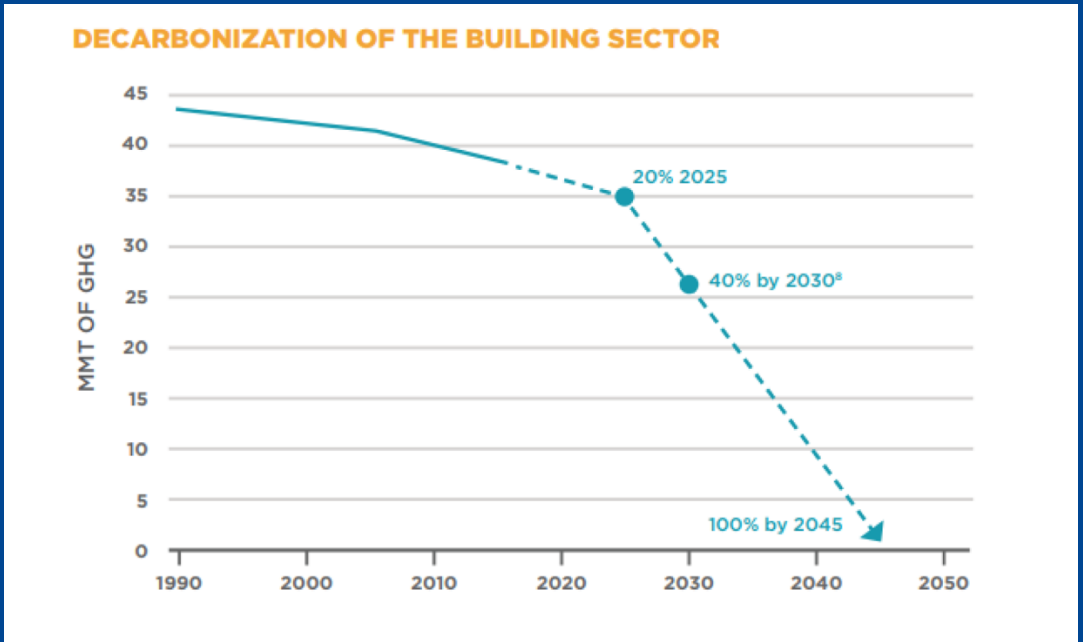
Customer
End-Use

Commercial Applications

Research

- Hydrogen and RNG integration for commercial applications.
- Develop commercial water heating, space conditioning, and process equipment (e.g. heating, cooling, refrigeration).
  - Energy Efficiency Improvements.
  - Achieve NOx reduction requirements.
- System integration: the scale of commercial systems allows for greater integration of applications.
  - e.g. water heating and space conditioning can be cost-effectively coupled to reduce energy consumption for both (dual functionality)
- Some interchangeability between residential and commercial technologies.

Technical Targets



Source: http://www.buildingdecarb.org/resources/a-roadmap-to-decarbonize-californias-buildings

Commercial Applications

Benefits

Customer End-Use

GHG Benefit

Developing advanced end-use equipment that is compliant with RNG and hydrogen provides an environmental benefit by reducing GHG emissions from commercial buildings.

Emissions Benefit

Increasing energy efficiency and burner performance for commercial equipment provides an environmental benefit by reducing NOx and PM emissions.

Cost Savings Benefit

Increased energy efficiency improves cost savings. This reduces overhead expenditures for businesses and an attractive ROI to adopt high efficiency technologies.

Operational Efficiency

Increasing energy efficiency and burner performance for commercial equipment also provides improved operational efficiency for customer by reducing fuel cost associated with space conditions, water heating, and other commercial operations.

Customer
End-Use

Commercial Applications

Key Considerations

Policy Alignment

This sub-program supports the following policies:

- AB32 (Reduce CO2 emissions 40% below 1990 levels by 2030)
- EO B-55-18 (Carbon-neutral California economy by 2045)
- AB3232 (Building Decarbonization)
- CA Title 24 (Buildings Energy Efficiency)
- CA Title 20 (Appliance Energy Efficiency)
- 2016 AQMP (Air Quality Management Plan, NOx and PM emissions regulation)
- AB617 (Disadvantaged communities for air quality improvements)

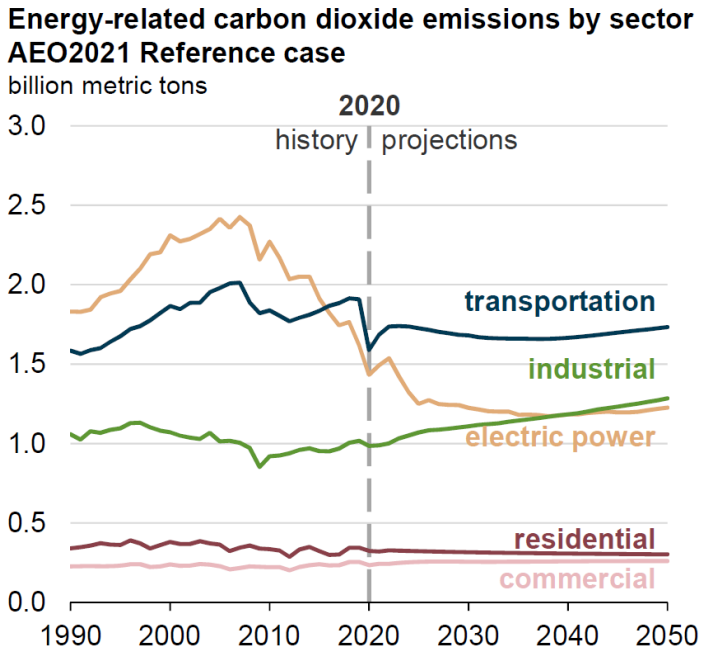
Equity

Buildings are part of the community. Where office buildings are located determine who will have access to the jobs it houses, how much energy it uses, and how much waste it produces. Therefore, the goal of this sub-program is to provide highly efficient and socially responsible technology to the built environment that improves the quality of life for all people.

Industrial Process Heat
Background

Purpose

Develop advanced heating technologies and systems for use in the industrial sector. The industrial process heat end-use sector represents some of the largest users of gaseous fuels and the most difficult applications to decarbonize. Some example subsector include manufacturing (e.g. food products, metals, glass), cement production, chemical processing, and agriculture.



B-55-18 calls for statewide carbon neutrality by 2045--an aggressive target that requires decarbonization of all sectors, especially the industrial sector, identified as an attractive sector for significant reduction of natural gas consumption, cost, and emissions

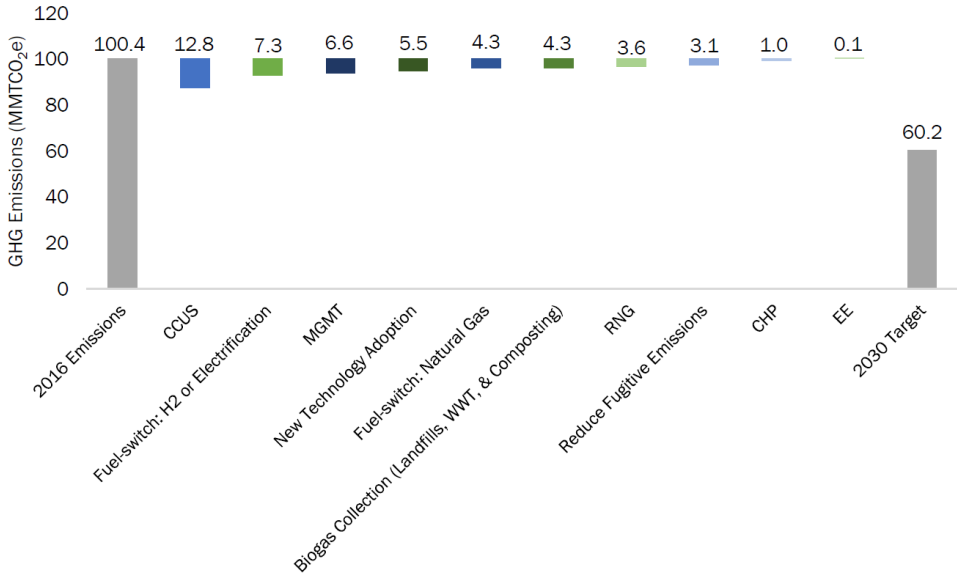
Customer
End-Use

Industrial Process Heat
Research

- Hydrogen and RNG integration for Industrial Process Heat applications.
- Develop high performance burners, waste heat recovery devices, carbon capture and utilization, smart systems, and sensors.
  - Energy Efficiency Improvements.
  - Achieve NOx reduction requirements.
- Encourage adoption of new high efficiency equipment or retrofit options through demonstrations. Support our industrial customers with education and outreach (e.g. webinar, conferences, virtual presentations).
- Focus on high GHG emissions subsectors due to higher decarbonization potential

Technical Targets

Figure 4-13
Illustrative Mitigation Portfolio Pathways by Industry Subsector



It is estimated that an emissions reduction of 48.6 $MMTCO_2e$ could be possible by 2030 through a combination of CCUS, fuel-switching, facility best management practices, new technology adoption, biogas collection, RNG, reducing fugitive emissions, CHP, and energy efficiency. Source: EFI, 2019. Compiled using data from CARB, 2018.

Source: EFI 2019

Industrial Process Heat

Benefits

Customer End-Use

GHG Benefit

Developing advanced industrial equipment that is compliant with RNG and hydrogen reduces GHG emissions from industrial process, which are difficult and costly to electrify.

Emissions Benefit

Increasing energy efficiency and burner performance for industrial equipment provides an environmental benefit by reducing NOx and PM emissions.

Cost Savings Benefit

Developing solutions which can be implemented as modifications or retrofits to existing equipment allow for cost-effective and energy efficient decarbonization of industrial end-uses.

Operational Efficiency

Increasing energy efficiency and burner performance for industrial equipment also provides operational efficiency improvements for industrial customers by reducing fuel costs associated with high-temperature processes, improving throughput, and higher quality products.

Customer
End-Use

Industrial Process Heat

Key Considerations

Policy Alignment

This sub-program supports the following policies:

- EO B-55-18 (Carbon-neutral California economy by 2045)
- AB32 (Reduce CO2 emissions 40% below 1990 levels by 2030)
- 2016 AQMP (Air Quality Management Plan , NOx and PM emissions regulation)
- CA Title 24 (Buildings Energy Efficiency)
- CA Title 20 (Appliance Energy Efficiency)
- AB617 (Disadvantaged communities for air quality improvements)

Equity

Industrial facilities typically neighbor low or disadvantaged communities. This sub-program aims to improve energy efficiency and replace conventional fuels with renewable natural gas and hydrogen which can significantly reduce emissions and improve air quality in these regions.

Customer
End-Use

Advanced Innovation
Background

Purpose

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

> **"About half of the nation's 125 million existing buildings were built before 1980, prior to modern building codes. Only a tiny percentage have undergone deep energy retrofits because doing so typically requires highly individualized, costly, complex, and disruptive upgrades. " – DOE**

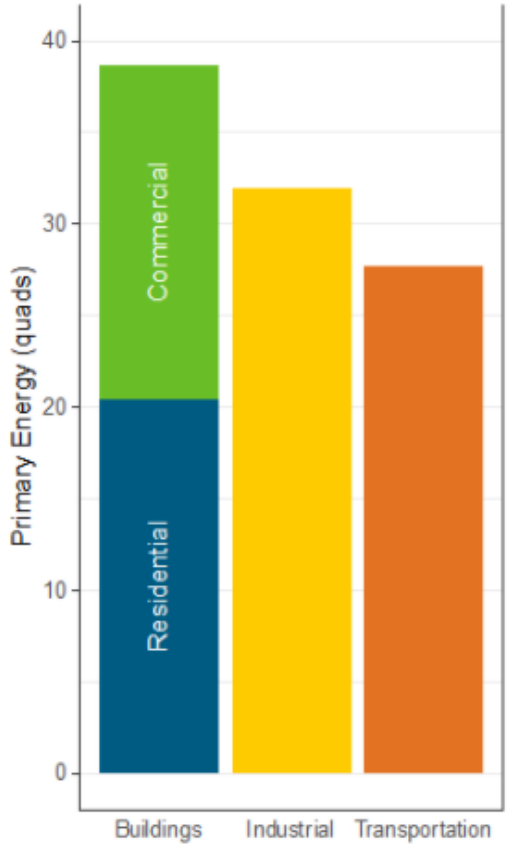


Figure 1: Primary energy consumption in 2018 from residential and commercial buildings was greater than consumption from the industrial or transportation sectors.

Source: EIA Annual Energy Outlook 2019

Customer
End-Use

Advanced Innovation
Research

- Investigating the use of smart technology (smart thermostats, sensors, etc.) to optimize energy efficiency and reduce gas consumption.
- Investigating advanced construction technologies and building materials (e.g., phase change polymers) that can improve energy efficiency in buildings.
- Assess new innovations such as machine learning, block-chain, 3D multi-sensor transmitters, robotics, or augmented reality, for applicability to emissions reduction, increased efficiency, and improved safety.

Technical Targets

- Highly energy-efficient with low carbon footprints
- Affordable to developers and consumers
- Faster renovation and construction, with less disruption to building occupants
- Added value, such as better indoor air quality, improved comfort, and reduced maintenance

Source: Department of Energy; https://www.energy.gov/sites/default/files/2021/03/f83/bto-abc-fact-sheet-030321.pdf

Advanced Innovation
Benefits

Customer
End-Use

GHG Benefit

By reducing energy usage, these innovations provide environmental benefit by reducing associated GHG emissions.

Emissions Benefit

By reducing energy usage, these innovations provide environmental benefit by reducing associated NOx and PM emissions.

Cost Savings Benefit

Identifying new technologies that provide energy efficiency results in lower customer energy costs.

Safety

These innovations increase customer safety by monitoring for equipment failures (e.g., leaks, performance degradations, emissions increases). Reduced fuel consumption, smart air monitoring, and advanced ventilation also improve local air quality.

Operational Efficiency

These innovations aim to provide operational efficiencies by directly targeting building performance and optimizing energy systems to yield the highest total efficiency.

Customer
End-Use

Advanced Innovation
Key Considerations

Policy Alignment

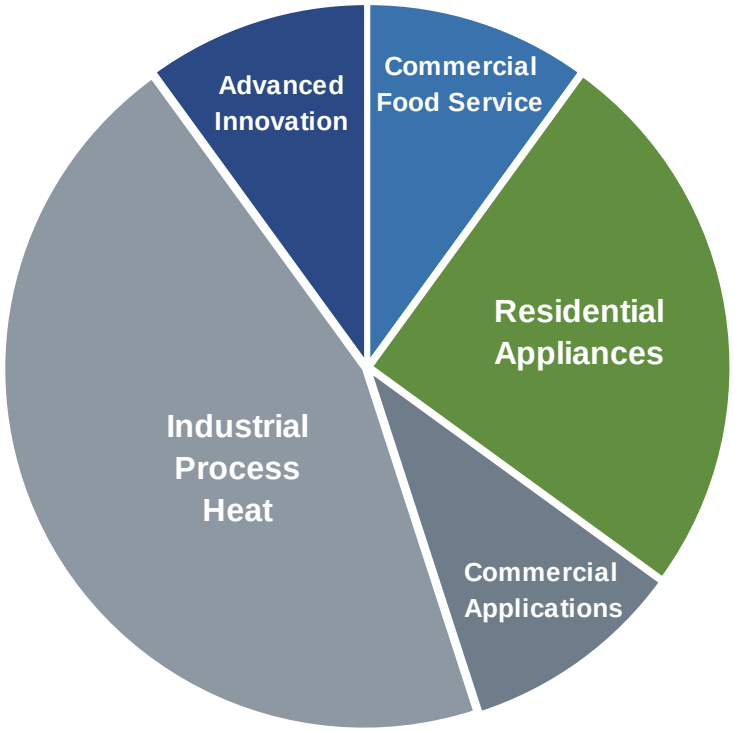
This sub-program supports the following policies:

- CA Title 24 (Buildings Energy Efficiency)
- CA Title 20 (Appliance Energy Efficiency)
- AB3232 (Building Decarbonization)
- 2016 AQMP (Air Quality Management Plan, NOx and PM emissions regulation)
- AB32 (Reduce CO2 emissions 40% below 1990 levels by 2030)
- EO B-55-18 (Carbon-neutral California economy by 2045)
- Leadership in Energy and Environmental Design (LEED)

Equity

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

2022 Proposed Funding Allocation



Sub-Program	Allocation
Commercial Food Service	10%
Residential Appliances	25%
Commercial Applications	10%
Industrial Process Heat	45%
Advanced Innovation	10%
Total	**$2,078,244**

Customer
End-Use

Specific Areas We Would Like Feedback

1. Given the variety of technologies and applications, what are suitable technical targets for Industrial Process Heat and Advanced Innovation?
2. What are some exciting technologies coming out of the advanced innovation space that we should be aware of?
3. What are the targeted sectors and processes for industrial end-use for future research?
4. The global pandemic may have permanent impact on CFS and Commercial buildings, should we change our research priorities as a result of that? How can we adapt to the changing market?
5. Given the breadth of technology that falls under CEUA, are there sectors or processes or application to avoid?

IX. Gas Operations

- Overview & Goals
- Spotlight Projects
- Sub-Programs Overview
  - Environmental & Safety
  - Operations Technology
  - System Design & Materials
  - System Inspection & Monitoring
- 2022 Proposed Funding Allocation
- Specific Areas We Would Like Feedback

SoCalGas

Overview & Goals

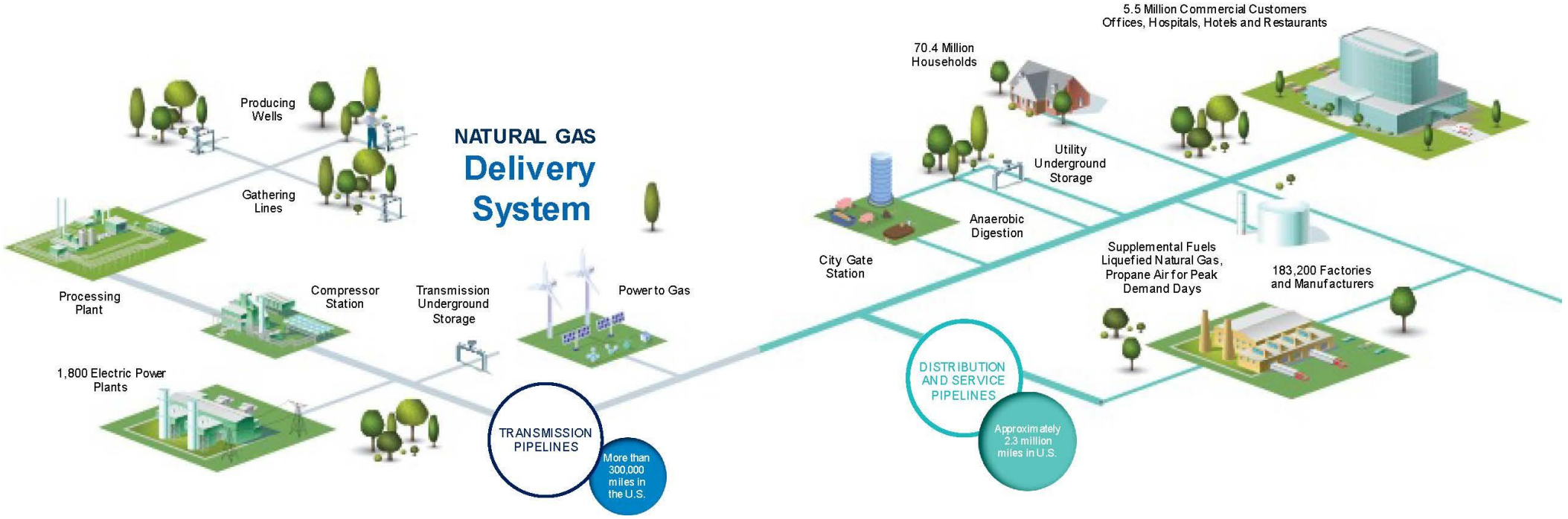
The Gas Operations RD&D Program works across the SoCalGas distribution, transmission, and storage system, **leveraging new technologies** and **advances on existing systems and processes**.

Goals

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

Gas Operations

SoCalGas
- 22 Million Customers
- 6 Million Meters
- 3,385 miles of Transmission
- 103,477 miles of Distribution Mains & Service Pipelines



Courtesy American Gas Association

Consortium Memberships

OTD Operations Technology Development

- Members: 26 Natural Gas Utilities (North America)
- Mission: Identify, select, fund, and oversee research projects resulting in innovative solutions and the improved safety, reliability, and operational efficiency of natural gas systems.
- Program Areas: 1) Pipe & Leak Location, Pipe Materials, 2) Repair & Rehabilitation, 3) Inspection & Verification, 4) Construction/Infrastructure Techniques, 5) Methane Emissions/Detection & Gas Quality, 6) Intelligent Utilities, 7) Risk & Decision Analysis Models.

The Flame of Innovation SMP

- Members: 28 Natural Gas Utilities (North America)
- Mission: To build a strong technology base in natural gas operations, energy utilization, environmental science and renewable energy; to create new, innovative solutions through "proof of concept" that address the most important industry needs; and to provide early-stage R&D that serves as the building blocks of subsequent commercial research efforts.
- Gas Operations Program Areas: 1) Distribution & Pipeline Technology, 2) Environmental Renewables & Gas Quality, 3) Energy Utilization.

Consortium Memberships

Pipeline Research Council International

LEADING PIPELINE RESEARCH

- Pipeline membership is open to companies operating natural gas transmission and other "energy pipelines" (Domestic & International)
- Mission: To collaboratively deliver relevant and innovative applied research to continually improve the global energy pipeline systems
- Technical Committees: 1) Compressor & Pump Station, 2) Corrosion, 3) Design, Materials & Construction, 4) Integrity & Inspection, 5) Measurement, 6) Surveillance, Operations & Monitoring, 7) Underground Storage

NYSEARCH.org Natural Gas RD&D

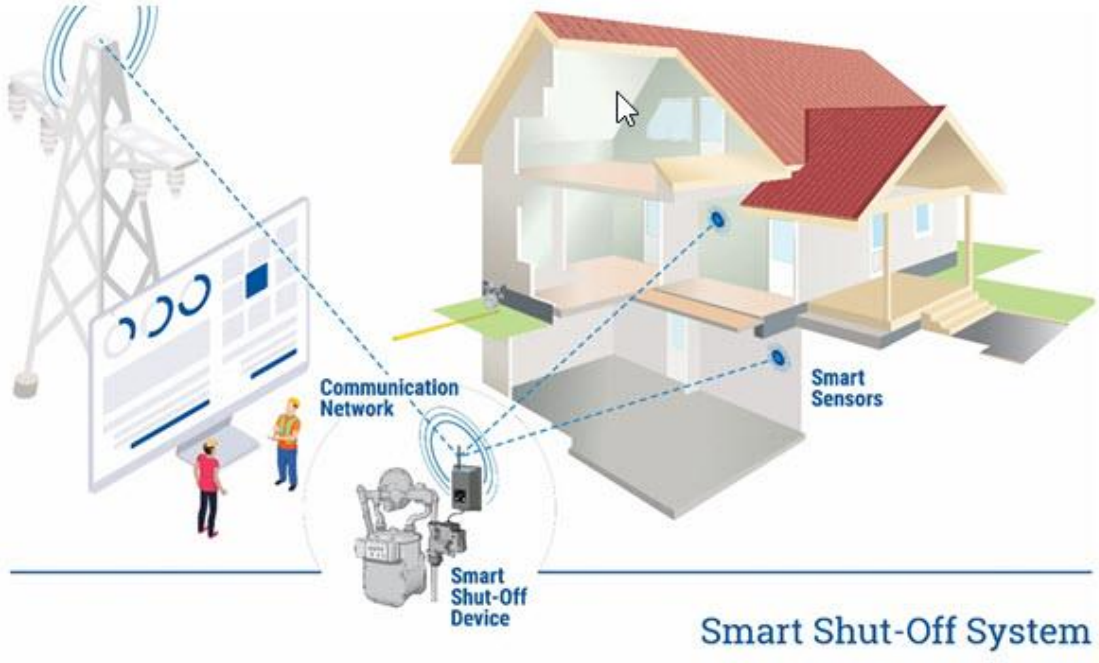
- Members: 20 Natural Gas Utilities (North America)
- Mission: To create and sustain collaborative consortia that are driven to innovate and deploy safe, efficient and reliable technologies that benefit customers, communities, and the natural gas industry.
- Program Areas: 1) Pipeline Integrity/Direct & Remote Assessment, 2) Pipe Location & Damage Prevention, 3) Leak Detection, Real-time Sensing & Inspection for Distribution, 4) Environment/Reducing GHG Emissions, 5) Gas Quality, 6) Evaluation of New Materials, 7) Advanced PE Piping and Joining, 8) Oracle (emerging technologies from other industries)

Spotlight Projects

Smart Shutoff Technology for Commercial and Residential Buildings (OTD 5.20.k)

Total Project Cost	$25,019
Start → Finish	8/4/2020 - 8/4/2023
Participants	OTD Members, CEC

SoCalGas-funded research has resulted in the development technologies that enhances the safety of the natural gas systems. One area of advancement in technology is the development of smart shut-off systems comprised of remote sensors and shut-off devices. Deployment of smart shut-off systems can provide localized detection of hazardous conditions and prevent loss of natural gas to the atmosphere and potentially save property and prevent injury and death. Subsequent to the research and development work under the OTD consortium the CEC also funded additional projects to further advance commercialization.



Gas Technology Institute (GTI)

Spotlight Projects

Greenhouse Gases Emissions Reduction (PRCI SRP-GHG-01)

Total Project Cost	$4,639,527
Start → Finish	1/1/2021- 12/31/2023
Participants	PRCI Members

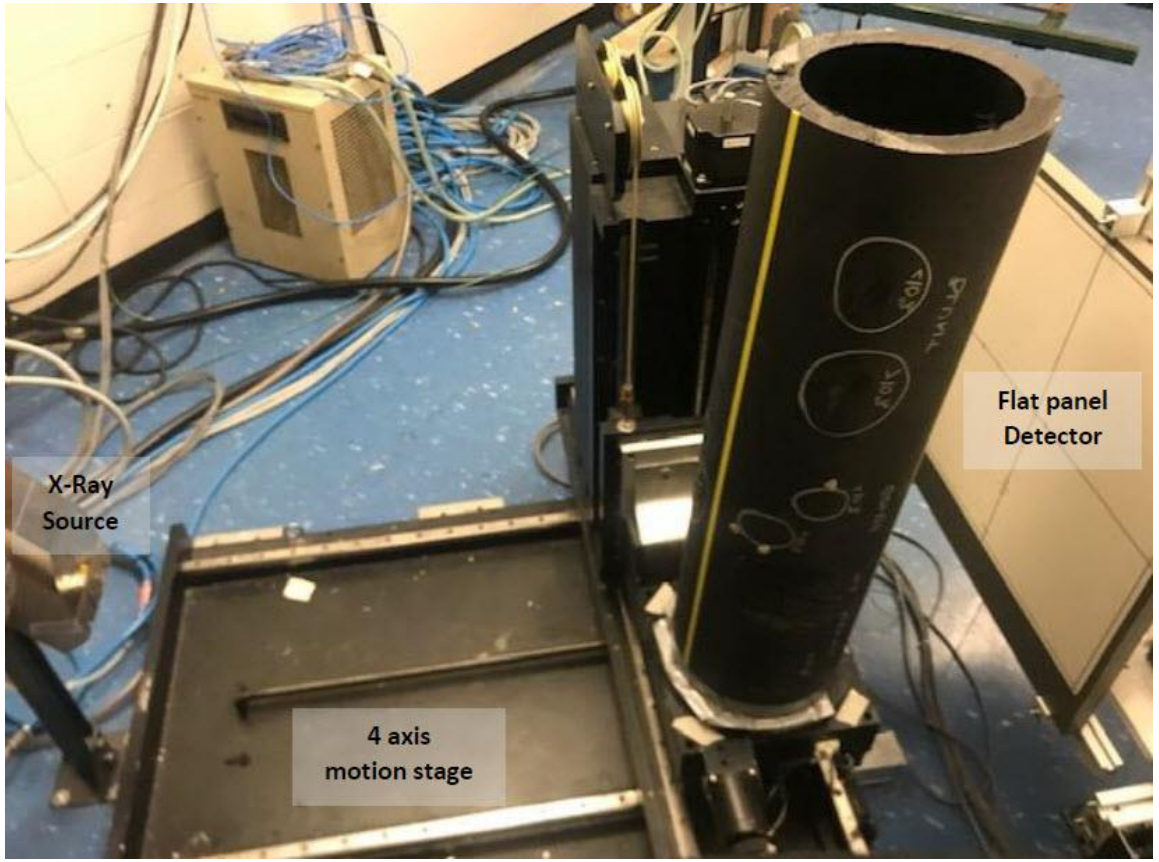
Climate change is a driver that is impacting all pipeline operators. The natural gas industry has made significant improvements to aggressively reduce GHG methane emissions and to develop solutions to address regulatory, financial, environmental, and social aspects. The largest GHG contribution in transportation by pipeline is the fuel used to drive compressors and pumps. Marginal improvements in efficiency of high-utilization equipment can have a significant impact in reducing GHG emissions. As gas compositions evolve to reduced GHG emissions Compressor research will continue to be an important area to focus R&D efforts to manage GHG emissions from pipeline transportation.

Spotlight Projects

Xray and Terahertz Development for NDE of PE Pipe (NYSEARCH M2019-007 Phase II)

Total Project Cost	$394,494
Start → Finish	1/20/2021 – 1/31/2023
Participants	NYSEARCH Members

This is a multi-year project that will see an emissions & cost savings benefit through ensured integrity of joints & reduced labor/material used for future system repair, respectively. Phase I's feasibility study evaluated defects in PE pipe and joints with Xray & THz. Results show both NDE methods detect volumetric defects & artificially introduced contaminants. Phase II will advance the qualitative defect characterization & attempt to quantify features through additional studies that will progress development of future work & the optimization of a field-portable THz & Xray NDE system. Another NYSEARCH project, M2018-009 Phase II, performed under NJIT is also underway.



Credit: NYSEARCH

Spotlight Projects

Impact of Hydrogen/Natural Gas Blends on LDC Infrastructure Integrity (NYSEARCH M2020-002)

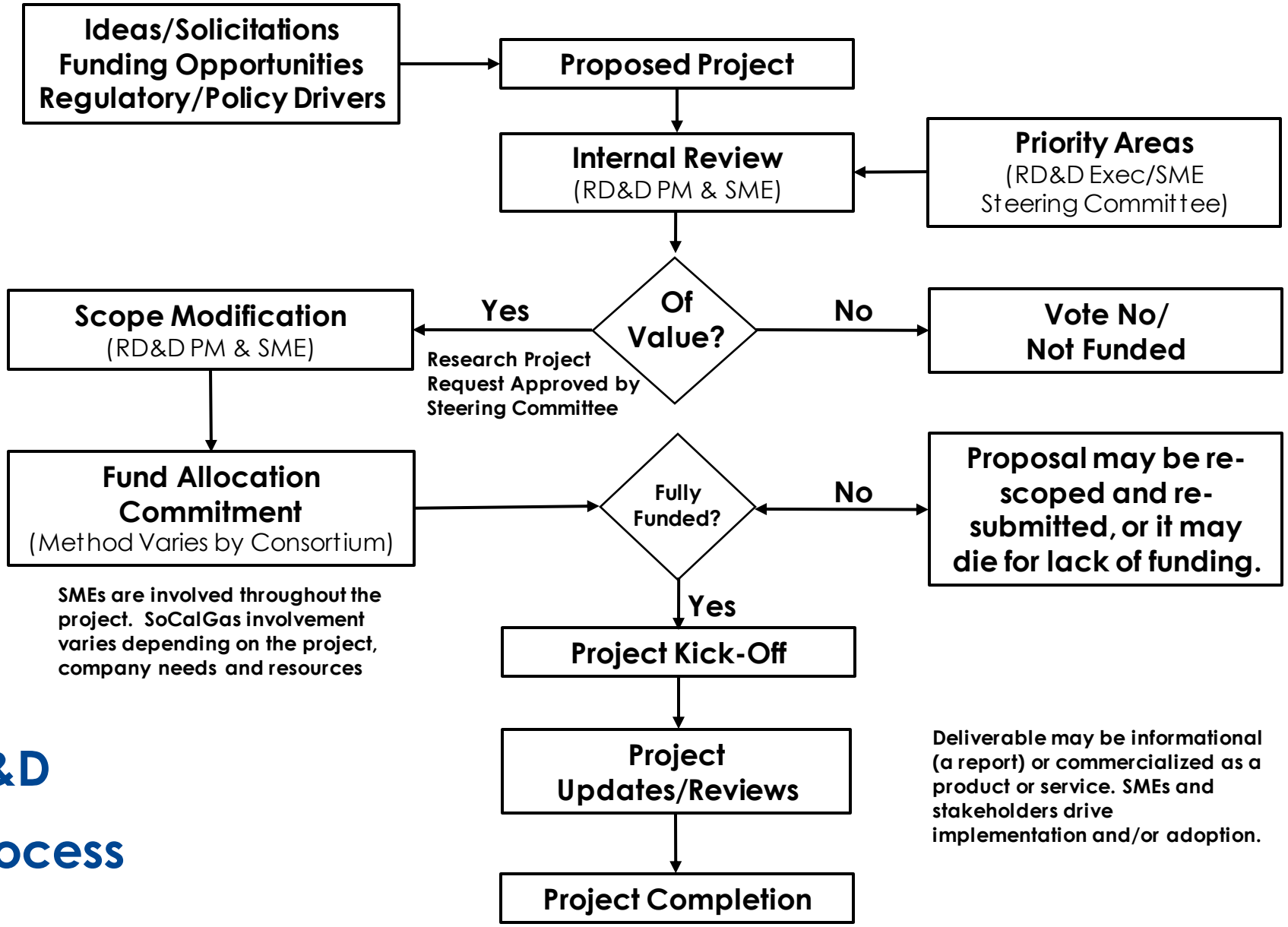
Total Project Cost	$138,801
Start → Finish	6/30/2020 – 6/30/2021
Participants	NYSEARCH Members

NYSEARCH previously funded a multi-phase project to study the effect of varying gas compositions on the operating components of the gas distribution network. This project builds upon 10 years of prior material science research on elastomers to study the effects of changing gas composition with H2 blending. Previous phases initiated the work with surveys and background information and encompassed full scale elastomeric coupling testing. Phase II objective is to determine if blending H2 into natural gas will change the physical properties of elastomers in a natural gas delivery system. A report will provide the response of a limited set of elastomeric materials under limited operating conditions to the presence of H2.

Credit: NYSEARCH

Gas Operations RD&D

Project Approval Process



Benefits

GHG Benefit

Develop technologies and best practices for reducing GHG emissions and to mitigate the impacts of the gas system on climate change.

22%

Emissions Benefit

Reduce environmental impact of the pipeline system and system operations including improving air quality by reducing emissions, such as post-combustion criteria pollutants.

7%

Cost Savings Benefit

Drive development of technologies and innovations that reduce operational costs resulting in increased affordability for ratepayers.

38%

Reliability

Develop methods and technologies for pipeline construction, alteration, and repair; minimize impacts to customers by avoiding service interruptions along with extending the service life of the pipeline infrastructure.

80%

Safety

Develop advanced systems to identify and mitigate threats to the pipeline system, protect pipelines from damage, and other aspects related to the safety of the general public, company employees, and contractors working on or around the pipeline and system facilities.

80%

Operational Efficiency

Consider operational efficiency as a driver when identifying and comparing technologies. For example, identify practices that leverage automation of data gathering and analytics to advance pipeline safety and regulatory compliance.

13%

% is of current projects with Benefit as of 3/31/2021

Sub-Programs

Gas Operations

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

Environmental & Safety
Background

Purpose

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

> Environment is no one's property to destroy; it's everyone's responsibility to protect. – Mohith Agadi

Environmental & Safety
Research

- Advanced technologies to address post-combustion criteria air pollutant emissions and fugitive GHG emissions.
- Projects that focus on developing methods to prevent or mitigate contaminated water run-off or hazardous waste and preserve plants and endangered species during pipeline construction and repair within environmentally sensitive areas.
- Safety projects concerned with protecting the pipeline from intentional and unintentional damage include those developing advanced sensors and automatic shutoff systems for above- and below-ground piping systems

Key Research Areas

- Damage prevention
- Combustion emissions
- Pipeline safety
- Employee safety

Environmental & Safety
Key Considerations

Policy Alignment

Explanation of how this sub-program supports CA policy.

- AB 32 (Reducing CO2 emissions)
- Clean Air Act (Air quality standards for NOx and PM)
- Various Air Quality Standards (federal and state)
- National Environmental Protection Act
- U.S. EPA Methane Challenge Program (oil and gas companies reducing CH4 emissions)
- CARB Oil and Gas Rule (reducing CH4 emissions)

Decarbonization & Diversity of Energy

Operations Technology
Background

Purpose

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.

> "Continuous improvement means that we never perceive current success as our final achievement."
> – John Hunter

Operations Technology
Research

- Develop cost-effective polyethylene (PE) pipe repair technologies that are easily applied over the damaged section of PE pipe.
- 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.
- Validate the capabilities of state-of-the-art measurement equipment and devices for both natural gas and other constituents.

Key Research Areas

- Steel and Plastic Pipeline Construction, Operations and Repair Technologies
- Mapping and Locating Technologies
- Measurement, Equipment and Tools

Operations Technology
Key Considerations

Policy Alignment

- DOT 49 CFR Part 192 (Federal pipeline safety regulations)
- CPUC General Order 112F (Gas transmission and distribution rule)

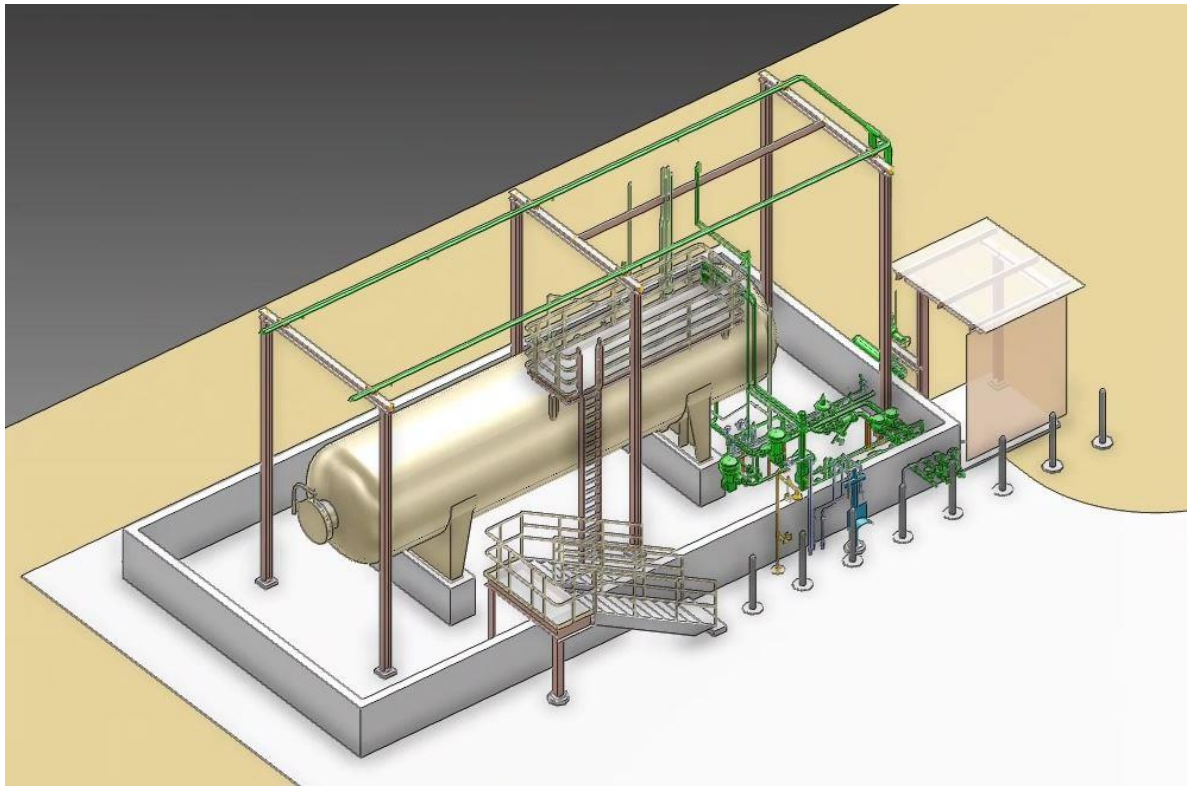
Decarbonization

Diversity of Energy and Digitalization

System Design & Materials
Background

Purpose

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.



> "We are developing local solutions to our most pressing challenges – from climate change to energy poverty"
>
> - David Anderson
>
> Chair, American Gas Association

System Design & Materials
Research

- Identify trace constituents and support establishment of upper limits for accepting RNG. Identify barriers that could prevent the introduction and blending of 10%-20% hydrogen into existing pipeline infrastructure.
- Improved understanding of the implications of potential risk factors, such as stresses due to internal gas pressure, construction procedures, and environmental factors.
- 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.

Key Research Areas

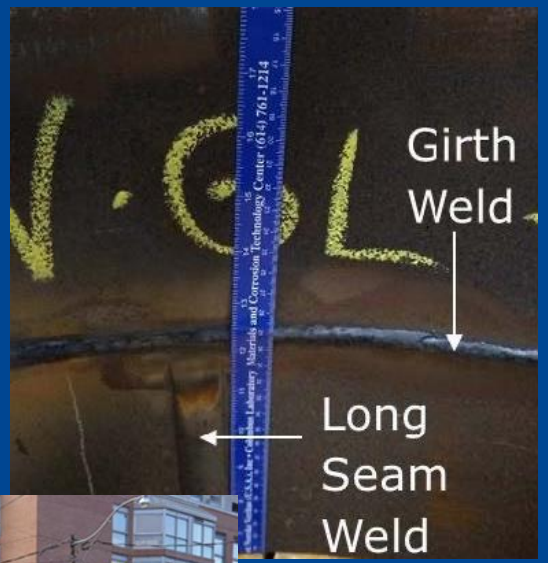
- Gas Composition and Quality
- System Design
- Materials and Tracking and Traceability of Materials

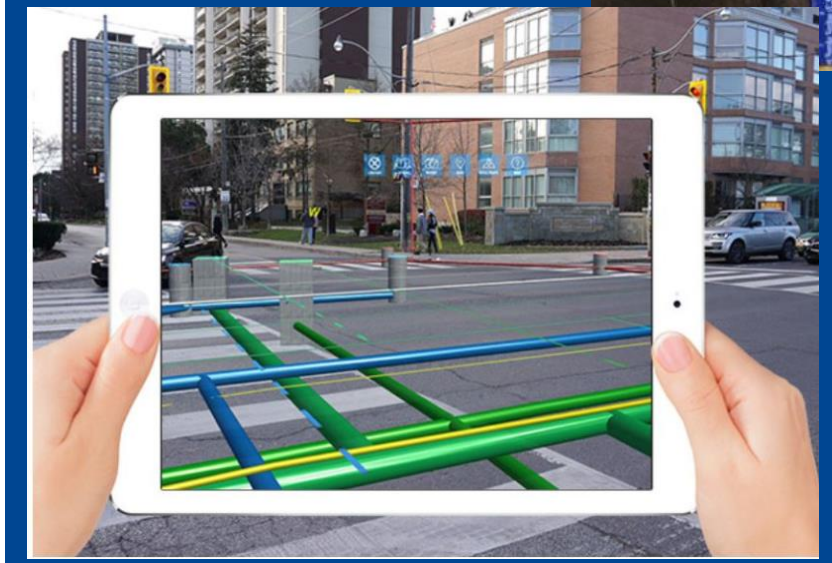
System Design & Materials
Key Considerations

Policy Alignment

- AB 32 (Reducing CO2 emissions)
- CPUC General Order 112F (Gas transmission and distribution rule)
- DOT 49 CFR Part 192 (Federal pipeline safety regulations)
- AB 1900 (Biomethane quality standards)
- Biomethane OIR Phase 3 (R.13-02-008) (Biomethane Standards and Requirements)

Decarbonization
Diversity of Energy
and Digitalization





System Inspection & Monitoring
Background

Purpose

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

> "If you can't measure it, you can't improve it."
>
> - Peter Drucker

System Inspection & Monitoring
Research

- 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.
- Evaluating a number of remote inspection and monitoring systems.
- Monitor environmental threats, such as weather-related landslides and floods, as well as seismic ground faults impacting pipeline integrity.

Key Research Areas

- Pipeline Systems Inspection Technologies – Inline and NDE
- Remote Pipeline Monitoring Systems (Sensors)
- Data Analytics (Big Data, Data Lake, IoT)
- Geohazard Threat Inspection and Monitoring

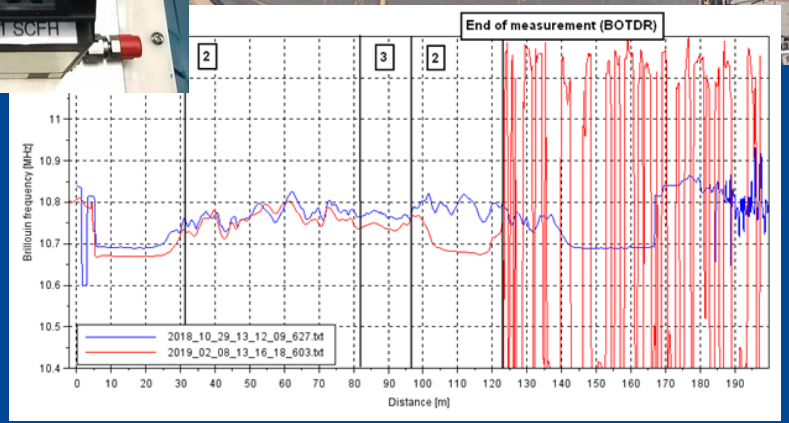
System Inspection & Monitoring

Key Considerations

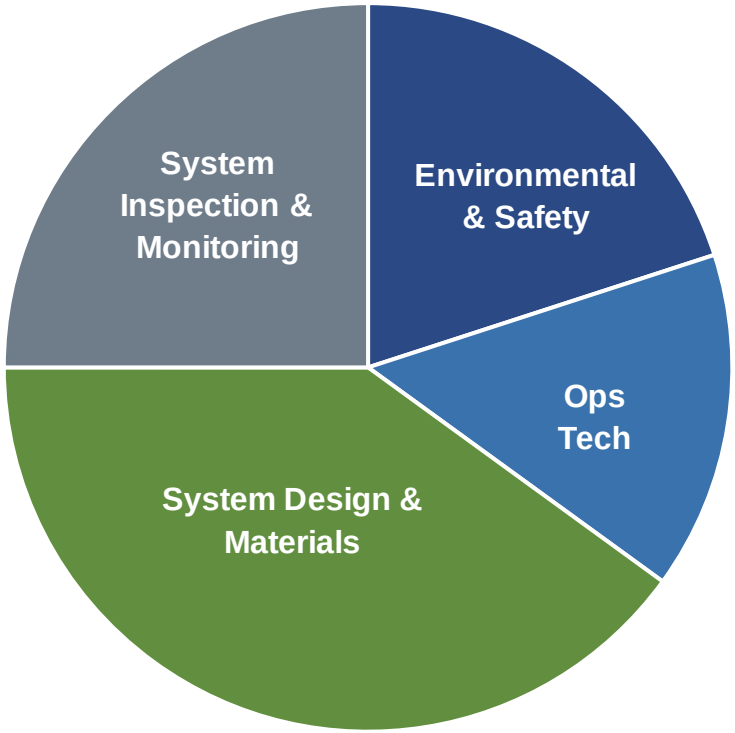
Policy Alignment

- CPUC General Order 112F (Gas transmission and distribution rule)
- DOT 49 CFR Part 192 (Federal pipeline safety regulations)
- AB 32 (Reducing CO2 emissions)
- Clean Air Act (Air quality standards for NOx and PM)
- CARB Oil and Gas Rule (reducing CH4 emissions)

Decarbonization, Diversity of Energy, and Digitalization



2022 Proposed Funding Allocation



Sub-Program	Allocation
Environmental & Safety	20%
Operations Technology	15%
System Design and Materials	40%
System Inspection & Monitoring	25%
Total	**$3,562,704**

Specific Areas We Would Like Feedback

1. Can you identify any technology gaps that should be considered for research within the Gas Operations program?
2. In areas of Equity Consideration, are there key priorities or research areas on which the Gas Operations RD&D program should focus?
3. What Gas Operations RD&D subprograms and research areas within the subprograms are of interest to you?
4. What are the key drivers amongst the Gas Operations program and sub-program areas? How do these drivers compare to other drivers? Why are these drivers more important than others?

WRAP-UP

We Will Continue to Invest Towards a Net Zero Future.

While we have made significant progress already, we know we must do more as we orient our business towards a net zero future. We will continue to invest in our infrastructure to build a resilient system capable of delivering reliable, affordable, and increasingly decarbonized energy to our customers.

WHAT'S TO COME

Presentation Objectives & Structure

Provide results from 2020

- ✓ Input and guidance from CPUC in draft resolution
- ✓ RD&D Overview and Structure
- ✓ 2020 in Review

Give an update on 2021

- ✓ Status and Changes for 2021

Seek input for 2022

- ✓ RD&D Plan Development
- ✓ Low Carbon Resources
- ✓ Clean Transportation
- ✓ Clean Generation
- ✓ Customer End-Use
- ✓ Gas Operations

AGENDA

We got through a lot today. Thank you for your time and attention.

	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 END-NOTES

- Remaining workshop time will be used for addressing questions and comments.
- Please submit questions in the GoToMeeting questions box, or please raise your hand to be called on.
- **Due to time constraints, questions and comments will be limited to 1 minute.**
- Participants will have until **Friday, April 30th** to submit written questions and comments to **rddinfo@socalgas.com**.

Questions and comments

Specific Areas We Would Like Feedback

1) Do you have any questions from earlier in the workshop?
2) Are there other organizations engaged in gas research and development we should be speaking with?
3) Are there areas of research or new technologies that we've overlooked?
4) Are there any new legislative or policy priorities we should consider in our planning process?
5) 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?

ADJOURN

APPENDIX SLIDES

Acronyms and 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

Stakeholder Outreach

Organization	Title(s)
Caltech	Executive Director, Resnick Sustainability Institute
Caltech	Executive Director, Resnick Sustainability Institute
CARB	Research Division Chief
CARB	Mobile Source Control Division
CDFA	Science Advisor to the Secretary
CEC	Deputy Director of Research
CEC	Manager of Systems Research Office
CEC	Manager of Energy Efficiency Office
CEC	Natural Gas R&D Program
CEC	Renewable Energy and Advanced Generation
CEC	Assistant Deputy Director of Research and Development Program
CEC	Supervisor Natural Gas Infrastructure, Safety and Integrity Unit
CEC	Manager of Energy Generation Research Office
CEC	Natural Gas R&D Program
CEC	Energy-related Environmental Research
CEC	Transportation Research
CSU-LA	Professor, H2 Refueling Stations
DOE	Program Director at the Advanced Research Projects Agency-Energy (ARPA-E)
DOE	Bioenergy Technologies Office (BETO)
GO-Biz	ZEV Team
GTI	R&D Manager, Energy Delivery & Utilization
GTI	Director, Hydrogen Technology Center
GTI	Vice President, Energy Delivery & Utilization at GTI
LA Metro	Sr. Executive Office, Vehicle Acquisition
LA Metro	Manager, Electric Vehicle Program
LA Metro	Executive Officer, Environmental Compliance
LA Metro	Sustainable Development and Innovation – includes Energy and Renewable Fuels Program

Stakeholder Outreach

Organization	Title(s)
LADWP	Western Transmission Planning
LBNL	Senior Scientist, Hydrogen and Fuel Cell Technologies Lab Program
LBNL	Energy Conversion - Chemist Staff Scientist/Engineer
LBNL	Principal Research Associate, Energy Storage & Distrubuted Resources Division
Northwest Natural Gas	Gas Supply
Northwest Natural Gas	Sr. Mgr. Marketing & Channel Development; North American Gas Heat Pump Collaborative.
Northwest Natural Gas	Customer Acquisition
Northwest Natural Gas	Business Development
NYSEARCH	Executive Director, NYSEARCH, and Vice President, RD&D, NGA
NYSEARCH	Western States Program Manager
PG&E	Gas Operations
PG&E	R&D and Innovation
PHMSA	Senior Research Program Manager, Engineering & Research Division (PHP-80)
Port of LA	Manager, Technology Advancement Program (TAP)
SCAQMD	Assistant Deputy Executive Officer
SCAQMD	Program Supervisor, Technology Advancement Office
SCAQMD	Air Quality Specialist
SCAQMD	Air Quality Specialist
SDG&E	Advanced Clean Technology Innovation
SoCal Edison	Production Manager
Stanford	Managing Director, Natural Gas Initiative
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
UC Riverside	Adjunct Professor, Chemical and Environmental Engineering
UC Riverside	Adjunct Professor, Chemical and Environmental Engineering
UCLA	Associate Professor, Center for Diverse Leadership in Science
West Virginia University	Department of Chemical & Biomedical Engineering

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