CALIFORNIA
ENERGY COMMISSION

Energy Research and Development Division

STAFF REPORT

Natural Gas Research and Development Program

Appendices A-C

Gavin Newsom, Governor

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APPENDIX A:
FY 2021-2022 Natural Gas Proposed Budget Report Presentation

FY 2021-2022 Proposed Natural Gas Research Initiatives

Stakeholders Workshop

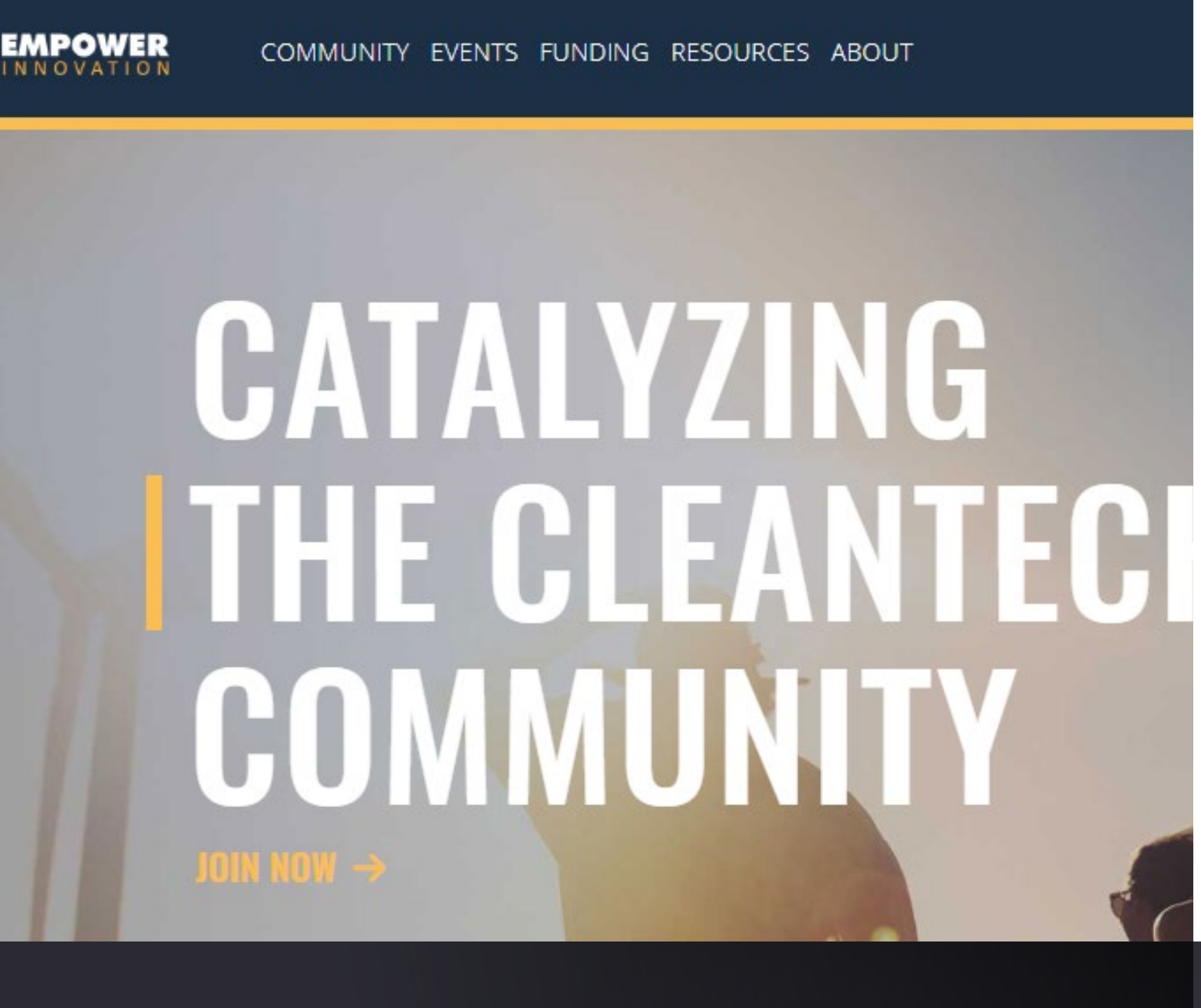
Energy Research and Development Division

Agenda

TIME	ITEM
10:00 am	Introduction and Purpose
10:30 am	Staff Presentations on Proposed Initiatives • Energy Efficiency • Natural Gas Infrastructure Safety and Integrity • Renewable Energy and Advanced Generation • Energy-Related Environmental Research • Transportation Research
11:30 pm	Public Comments

Announcements

- This workshop is being recorded and will be posted online.
- Participants will be muted during the presentation. Please type your comments and questions in the Q&A window.
- Natural Gas Plan documents and workshop materials, including this presentation, will be posted at: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=16-PIER-01
- Sign up for updates on the "naturalgas" or "research" Listserv: https://ww2.energy.ca.gov/listservers/index_cms.html



Connect with Us

The Energy Commission can be found on most social media platforms, Facebook, YouTube, Twitter, and LinkedIn.

Empower Innovation collects and promotes resources for the cleantech community. It also provides access to our resource libraries, tools, and databases. A place to create favorites and share lists with others.

Commitment to Diversity

The Energy Commission adopted a resolution strengthening its commitment to diversity in our funding programs. We continue to encourage disadvantaged and underrepresented businesses and communities to engage in and benefit from our many programs.

To meet this commitment, Energy Commission staff conducts outreach efforts and activities to:

- Engage with disadvantaged and underrepresented groups throughout the state.
- Notify potential new applicants about the Energy Commission's funding opportunities.
- Assist applicants in understanding how to apply for funding from the Energy Commission's programs.
- Survey participants to measure progress in diversity outreach efforts.

We Want to Hear From You!

Please take the 1-Minute Survey to help us track demographic participation. Responses are anonymous and the information will help us enhance our outreach.

Please use the link provided in the chat.
(See chat window during workshop.)

Thanks!

FY 2021-22 Natural Gas R&D Plan

- Energy Commission R&D Program staff are holding this workshop seeking stakeholder comments on proposed natural gas research initiatives for the Natural Gas FY 2021-2022 budget plan.
- Specific "Questions for Stakeholders" will be posed during the workshop.

Introduction

- Research and development specific to natural gas done in the public interest to support the transition to clean energy, greater reliability, lower costs, and increased safety for Californians
- "Directed towards developing science or technology, and 1) the benefits of which accrue to California citizens, and 2) are not adequately addressed by competitive or regulated entities."
- $24 million annually, funded by a surcharge on natural gas consumption in CA

Natural Gas R&D Projects

Natural Gas R&D funded projects:

- Focus on energy efficiency, renewable energy and advanced clean generation, energy transmission and distribution, energy-related environmental protection, and transportation.
- Support state energy policy.
- Provide complementary communitywide benefits including, but not limited to, job creation, improved air quality, and economic stimulation.

Policy Drivers

Integrated Energy Policy Report

- "Develop energy policies that conserve resources, protect the environment, ensure energy reliability, enhance the state's economy, and protect public health and safety"

EO B-55-18

- Establishes statewide goal to achieve carbon neutrality as soon as possible and no later than 2045.

SB 32

- Reduce GHG emissions to 40% below 1990 levels by 2030.

SB 100

- Requires 100% of retail electricity sales be met by renewable and zero carbon resources.

SB 1250

- Public Goods Utilities surcharge to support public interest for research and development.

SB 1383

- Reduce emissions of short-lived climate pollutants, including those from dairies, organics disposal, and wastewater treatment plants below 2013 levels by 2030.

General Approach to Developing Initiatives

- Identify research gaps to address and propose initiatives through:
  - Discussion with utilities, public stakeholders, state and federal governmental agencies, other CEC programs;
  - Roadmaps;
  - Public meetings with industry and trade associations; and
  - Research ideas submitted by the public
- Energy research priorities are guided by policy directives and equity considerations
- Need clearly identified natural gas ratepayer benefits
- Research projects are selected through competitive solicitations

Natural Gas Research Initiative Development

FY 2021-22 proposed research initiatives are framed around ***decarbonization and equity***.

Primary areas:

- Indoor Air Quality
- Industrial Decarbonization
- Hydrogen
- Decommissioning
- Safety and Integrity

Research Initiative Feedback

Here at the California Energy Commission, we're always working to make our research initiatives have the greatest impact.

Now, that you're here we would like to hear your thoughts.

Research suggestions can be provided to our Natural Gas Docket at: https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=16-PIER-01

Presenter: David Stout

Energy Efficiency

Energy Efficiency Program Goals

- Conduct research, development, and demonstration to advance strategies and technologies to support decarbonization in the building and industrial sectors.
- Enhance outreach and demonstration opportunities with under-resourced communities.
- Increase energy efficiency while reducing operating costs, natural gas use and greenhouse gases and other air emissions (for example low NOx).
- Develop and demonstrate affordable energy-efficiency technologies, processes, and strategies.

Past research focused on using natural gas more efficiently in buildings and industries.

Proposed Research Initiatives

FY 2021-22 Energy Efficiency

Industrial Decarbonization Issues

- On an annual basis, California's industrial sector consumes over 35% of the state's natural gas consumption and is responsible for over 20% of the state's greenhouse gas emissions
- Process heat accounts for about 85% of industrial natural gas use
- Industrial heating such as calcination, smelting, curing, and forming is difficult and/or expensive to electrify because of high temperature of these processes

Proposed initiatives targets <u>two areas</u>:

- Hydrogen and natural gas blending for industrial end-use applications
- Industrial Carbon Capture and Utilization

Research Initiative #1

Hydrogen and Natural Gas Blending for Industrial End-Use Applications

Background:

- Hydrogen blended with natural gas could be used as a fuel in industrial applications
  - Reduce natural gas consumption
  - Reduce greenhouse gas emissions
  - Provide pathway for decarbonization
- End-use application combustion safety and stability without affecting product quality are critical for using hydrogen and natural gas blends

Research Purpose & Description

1) Hydrogen and Natural Gas Blending for Industrial End-Use Applications

Purpose

- Identify and demonstrate industrial applications and processes where natural gas use can be replaced with blended natural gas and green hydrogen.
- Gather sufficient data to characterize the potential impacts of hydrogen-blending to the state's climate and energy goals and effects on criteria pollutant emissions.
- Establish criteria to define "safe" use of blends.

Description of Research

- Laboratory experiments to determine the maximum upper limit (MUL) of hydrogen that can be safely blended.
- Explore equipment retrofits and identify specifications that could enable safe use of higher blends of hydrogen to increase the MUL (e.g., controls, burner modifications).
- Evaluate the effect of blending on criteria air pollutant emissions (NOx).
- Demonstrate at pilot or full-scale use of blends in industrial process equipment.

Projected Ratepayer Benefits

1) Hydrogen and Natural Gas Blending for Industrial End-Use Applications

Technology Potential.

- Increasing the amount of hydrogen replacing natural gas in industrial end-use applications may be a cost-effective way for industry to of reduce CO2 emissions.
- Replacing 5% of the natural gas used by California's industrial sector with green hydrogen would eliminate 2.2 million metric tons of carbon dioxide emissions annually.

Environmental Benefits.

- Reduce GHG emissions from natural gas fueled industrial process heating and high-temperature processes that are difficult or costly to electrify or otherwise decarbonize.
- Potential for criteria air pollutant reductions, for example NOx and CO, which are known to be harmful to human health and the environment.

Equity Considerations. Many industrial facilities are in under-resourced communities. Inform implementation of hydrogen blending to reduce or avoid increasing criteria air pollutants (NOx) and their associated health affects in these communities.

Questions for the Stakeholders

1) Hydrogen and Natural Gas Blending for Industrial End-Use Applications

- What should be the targeted industrial sectors and processes? Why?
- Are there sectors or process applications to avoid? Why?
- What are specific research needs in the area of natural gas and hydrogen blends in industrial end-use applications?
- What are non-technological barriers that hinder the use of hydrogen and natural gas blends?
- Are there examples of industries that have successfully used hydrogen natural gas blends? Please provide links.
- What air quality considerations for using blends should we be aware of?

Research Initiative #2

Industrial Carbon Capture & Utilization

Background:

- Certain industrial processes are unlikely to be electrified in the upcoming decade because of their high temperatures;
- Carbon capture can mitigate GHG emissions, but expenses are higher than price of captured $CO_{2;}$
- Utilization of CO_2 by conversion into high-value saleable commodities can offset the costs of carbon capture and;
- Efficient utilization of carbon dioxide could promote adoption of industrial carbon capture.
- Target major emitters of carbon dioxide identified by mandatory reporting and cap-and-trade programs that use high-temperature processes. These include glass, cement, metals, chemicals.

Research Purpose & Description

2) Industrial Carbon Capture and Utilization

Purpose

- Improve efficiency and economics of existing and emerging technologies that capture carbon dioxide and convert into high-value commodities
- Increase effectiveness of capturing carbon dioxide and its purification
- Develop novel chemical and biological conversion technologies and improve economics of the existing ones

Research Description

- Develop a roadmap for carbon capture and utilization in the industrial sector
- Establish an energy baseline of existing CCU technologies
- *Carbon Capture* – Develop and demonstrate (1) advanced materials and purification processes could improve efficiency of CO2 separation and removal of impurities (water, oxygen, SO2, NOx) and (2) Novel separation processes that could reduce energy required for CO2 separation
- *Carbon Utilization* – Develop and demonstrate (1) chemical and biological conversion technologies convert CO2 into various types of fuels, precursors for plastics, and other valuable products, including food, (2) processes for using CO2 to cure concrete, and (3) conversion into carbon nanotubes

Questions for the Stakeholders

2) Industrial Carbon Capture and Utilization

- What are CO2 utilization technologies with highest market potential?
- What technologies have highest potential for on-site conversion of CO2 at the industrial facilities?
- What are specific research needs for industrial carbon capture and utilization in California?
- What are non-technological barriers that hinder adoption of carbon capture and utilization?
- What industries in California have most potential for carbon capture and utilization?
- What are examples of industrial carbon capture and utilization that would be helpful in our research?
- What are anticipated co-benefits of carbon capture on air quality (criteria air pollutants and particulates)? Links to supporting literature?

Natural Gas Infrastructure Safety & Integrity

Presenter: Qing Tian

Natural Gas Infrastructure Safety & Integrity Program Goals

- Conduct research in natural gas infrastructure (pipelines and storage) to increase public safety, system integrity, and climate resiliency
- Enhance transmission and distribution capabilities of the natural gas system
- Address issues not adequately addressed by the regulatory and competitive markets

Proposed Research Initiatives

FY 2021-22 Natural Gas Infrastructure Safety & Integrity

- Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages
- Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

Research Initiative #3

Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages

Background:

- Natural force damages contribute to 12.8% transmission incidents and 9% distribution incidents between 2005 and 2018
- Natural force damages can sometimes result in catastrophic failures and release large volumes of natural gas
- Existing patrol programs only observe surface conditions on and adjacent to the pipeline right-of-way but can’t reveal changes on mechanical properties in real-time

Research Purpose & Description

3) Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages

Purpose

- Identify potential risk in vulnerable areas
- Continuously monitor natural force threats and assess pipeline conditions
- Take appropriate action concerning changes in pipeline conditions
- Facilitate emergency responses

Research Description

- Development and demonstration of remote sensing and monitoring technologies
- Development of mitigation strategies to reduce the risk of potential damages
- A "whole system approach" from data collection to integration with utility integrity management system and risk assessment tools
- Advancing technology and commercial readiness level by optimizing device performance, improving cost effectiveness, and demonstrating the technologies at full-scale in the field

Projected Ratepayer Benefits

3) Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages

- **Energy Sector.** With the state-of-the-art remote sensing and monitoring technologies, pipeline operators can monitor ground movement around pipelines and develop mitigation strategies to reduce the risk of natural force damages and service disruption.
- **Technology Potential.** These technologies will enable utilities to conduct real-time, continuous, and comprehensive monitoring at geodetic monitoring points to track potential ground movement.
- **Market Connection.** Sectors and user groups of interest in the proposed initiative include natural gas utilities, pipeline owners and operators, and pipeline inspectors and surveyors.
- **Environmental Benefits.** Reducing damages to pipelines helps decrease direct and indirect greenhouse gas (GHG) emissions.
- **Equity Considerations.** Under-resourced communities are usually more vulnerable to natural disasters. This research will pilot and put engineering measures in place to protect these communities from being negatively impacted by natural force damages.

Questions for the Stakeholders

3) Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages

- What would be the most suitable technologies for monitoring pipelines and ground movement?
- What would be the best approach to integrate monitoring data into utility integrity management system?
- What are important project considerations in the R&D stage to eventually allow for commercialization and incorporation into utility operations?

Research Initiative #4

Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

Background:

- Plastic pipelines accounted for 72.7% of US natural gas services, and CA has 55,000+ miles of plastic pipeline mains for natural gas distribution
- The safety and integrity of plastic pipelines are impacted by third-party damages, natural hazards, material aging, repair degradation, etc.
- Plastic pipe repair practices are costly and inefficient, since they involve pipe excavation and gas service interruption

Research Purpose & Description

4) Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

Purpose

- Implement Federal Pipeline Safety Regulations on plastic piping systems
- Further enhance plastic pipeline safety and adopt innovative technologies
- Advance the overall integrity of plastic pipelines in California

Research Description

- Technologies for early notification of potential risks
- Robotic internal inspection and repair technologies
- New and cost-effective technologies to repair plastic pipe damages
- Technologies to measure the performance of repaired plastic pipe systems
- Emerging technologies that minimize or avoid natural gas service interruption during pipeline repair

Projected Ratepayer Benefits

4) Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

- **Energy Sector.** The technologies developed and demonstrated in this initiative are intended to improve the safety and integrity of natural gas plastic pipelines and prevent pipe failures and gas service interruption.
- **Technology Potential.** The deployment of the technologies would help to assess, repair, and prevent damages to plastic pipes widely used in natural gas mains and service lines.
- **Energy and Cost Savings.** The use of the technologies from this initiative will reduce plastic pipeline failures and decrease natural gas system down time and associated costs. Improved repair technologies for plastic pipes can further bring down the cost of pipeline system maintenance.
- **Environmental Benefits.** Integrity improvement of natural gas mains and service lines reduces fugitive methane emissions.
- **Equity Considerations.** The research will enhance the safety, reliability and resiliency of gas service including in disadvantaged and low-income communities, which are more vulnerable to natural gas incidents such as gas leaks, pipe ruptures and explosions.

Questions for the Stakeholders

4) Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

- What are the most desirable improvements on current technologies or practices for plastic pipelines?
- Which components of plastic pipeline systems are more vulnerable to aging, degradation or risks, so that the safety enhancements can focus more on these components?
- Are there any additional research areas of interest to improve the overall integrity of plastic pipeline systems?

Presenter: Rizaldo Aldas

Renewable Energy & Advanced Generation

Renewable Energy & Advanced Generation Program Goals

Overcome barriers and enable deployment of renewable energy, and reduce dependence on fossil natural gas by:

- Accelerating efficient and cost-competitive production of renewable gas –biomethane and renewable hydrogen – and demonstrating its diversified applications for clean and advanced power generation.
- Developing cost-effective, fuel-flexible, energy-efficient, low-emission, and hybrid energy generation systems and technologies.
- Advancing the development and market availability of clean and efficient distributed generation and renewable combined heating, cooling, and power technologies.

Research Initiative #5

Developing and Demonstrating Hydrogen-Based Power Generation Systems

Background:

- Hydrogen-based generation technologies – paired with advanced hydrogen production methods – can reduce the use of and emissions from natural gas in power generation.
- One promising pathway to reduce greenhouse gas emissions in natural gas-fired power generation is through blending of low-carbon hydrogen into the fuel mixture of gas generators.
- Although adding hydrogen to natural gas on end-use systems holds promise, use of hydrogen for power generation has not been commercially demonstrated in California.

Research Purpose & Description

5) Developing and Demonstrating Hydrogen-Based Power Generation Systems

Purpose

- Increasing hydrogen blends in natural gas requires modifications or changes on power generation technologies, with safety and material integrity implications.
- Better understand challenges, and identify solutions, in using higher blends of hydrogen in power generation.
- Demonstrate hydrogen-fueled power generation at a site that produces renewable gas as a source for hydrogen-rich fuel.
- Support demonstration of emerging technologies for producing hydrogen-rich fuel from renewable gas and emerging generation technologies.

Research Description

- Development and demonstration of power generation technologies that can run efficiently on high blends of hydrogen in the fuel stream.
- Advance and demonstrate generation system efficiency, emissions reductions (greenhouse gases and NOx), and safe operation (e.g., operating without leaks, maintaining system integrity); with applications for small-scale to large-scale systems
- Demonstrate integrated production of hydrogen-rich fuel from renewable gas and power generation.

Projected Ratepayer Benefits

5) Developing and Demonstrating Hydrogen-Based Power Generation Systems

- **Energy Sector.** The proposed technology development and demonstration would increase hydrogen adoption, potentially reducing statewide consumption of fossil-based natural gas in power generation.
- **Energy and Cost Savings.** Technology advancements that enable use of hydrogen blends in power generation systems could reduce consumption of fossil-based natural gas (and potentially other fuels) and associated costs.
- **Environmental Benefits.** Reducing fossil-based natural gas consumption and developing power generation applications for low-carbon hydrogen supports California's greenhouse gas emission reduction goals.
- **Equity Considerations.** Fossil fuel generators are typically in under-resourced communities. Hydrogen-based power generation systems will contribute to the state's clean electricity goals and provide opportunities to improve local air quality through reductions of nitrogen oxide (NOx) emissions and other natural gas combustion byproducts that present health risks.

Questions for the Stakeholders

Developing and Demonstrating Hydrogen-Based Power Generation Systems

- Are we effectively targeting research and technological development needs to support California's decarbonization goals and provide natural gas ratepayer benefits?
- What are the technological and non-technological barriers to deploying hydrogen power generation that should be prioritized?
- Do you have suggestions for research and development needed to improve the technical and economic aspects of the proposed technologies?
- What air quality considerations or benefits using blends should we be aware of?

Energy-Related Environmental Research

Presenter: Susan Wilhelm

Energy-Related Environmental Research Program Goals

Program Goals:

- Develop cost-effective approaches to evaluating and resolving environmental and human health impacts of energy production, delivery, and use in California;
- Explore how strategic planning and management can help California meet its energy and environmental goals;
- Support climate adaptation and resilience planning for California's energy system.

Proposed Research Initiatives

Energy-Related Environmental Research

- Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives
- Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

Research Initiative #6

Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives

Background:

- Prior research, including prominent contributions funded by the Natural Gas R&D program, has demonstrated that residential cooking with natural gas appliances generates pollutants that degrade indoor air quality (IAQ).
- In indoor residential settings with gas cooking, health damaging pollutants such as NO_2 and $PM_{2.5}$ can exceed health-based thresholds set for ambient air quality.
- Field measurements of actual exposures to indoor air pollution in California kitchens-- particularly in small multi-family homes-- as well as the nature of indoor PM2.5 is limited.

Research Purpose & Description

6) Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives

Research Issue

- Smaller homes—including apartments typically occupied by low-income residents— are typically associated with higher pollutant concentrations. While research funded by the Natural Gas R&D program is supporting development of Title 24 Building Energy Efficiency standards that will protect human health through ventilation requirements for new homes, the issue of exposures to vulnerable populations in existing homes requires further exploration to support appropriate interventions.

Research Purpose and Description

- Address critical gaps in our understanding of health impacts of cooking with residential natural gas and possible benefits of electric cooking appliances, including:
  - Exposure assessment of California residents to NO2 in residential environments;
  - Assessment of indoor exposures to PM2.5 associated with cooking episodes, as well as characterization of the chemical constituents, size distribution, or other attributes that factor into health impacts.
- Inform a more realistic assessment of health implications from exposures to health-damaging pollutants associated with residential cooking. May inform low-cost strategies for monitoring PM in residential kitchens.
- Responsive to CPUC's Resolution G-3571.

Projected Ratepayer Benefits

6) Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives

- **Energy Sector**. Provides empirical basis for understanding the health implications of cooking with various fuels in multi-family homes as well as associated ventilation needs.
- **Energy and Cost Savings.** Quantification of pollutant exposures as well as improved characterization of health-damaging pollutants generated by cooking with natural gas or gas substitutes provides a basis for quantifying health-related benefits associated with energy- and cost-saving cooking and ventilation technologies.
- **Environmental Benefits**. Provides a foundation for addressing indoor air pollution in multi-family homes and assessing the health benefits of building decarbonization measures.
- **Equity Considerations:** The proposed research will focus on quantification of health-damaging pollutants in multi-family homes in low income and disadvantaged communities, with an emphasis on capturing exposures of those most vulnerable to air pollution exposures (e.g., children, elderly).

Questions for Stakeholders

6) Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives

- How should the study population be defined? (e.g., multi-family households that include residents vulnerable to air pollution exposures, low-income single-family homes, etc.)
- How to foster cost-effective recruitment of the study population to ensure the research benefits the intended stakeholders?
- Are there ongoing efforts that could be leveraged or otherwise provide fruitful partnerships?

Research Initiative #7

7) Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

Background:

Prior research funded by the Natural Gas R&D Program established that *a strategic, long-term planning strategy for California's retail natural gas system is imperative* to meeting the state's decarbonization goals while containing cost, addressing equity concerns, and managing infrastructure safety considerations.

Responding to this urgent need, the FY 2020-2021 R&D Funding Plan provided funding to *develop a data-driven, actionable tool to support strategic and equitable natural gas decommissioning*.

Research Purpose & Description

7) Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

Purpose

- To complement identification of potential sites for decommissioning and electrification based largely on physical assets, location-specific analysis of operational issues is needed to assess the implications of decommissioning for remaining segments of the gas system.
- Bridge the gap between high-level gas system planning and local decommissioning pilots, providing CPUC, local governments, IOUs, and other stakeholders with a valuable tool for assessing the technical and economic feasibility of decommissioning specific segments of the gas system.

Research Description

- Deliver location-specific analysis of promising candidate sites for decommissioning (e.g., those with known pipe integrity and corrosion issues or other factors such as seismic risk and natural gas supply vulnerability), examining the implications of decommissioning on the remaining gas system.
  - Opportunities for examining natural gas decommissioning and electrification opportunities in low-income and disadvantaged communities will be prioritized.
- Initiative to be informed by CEC workshop in collaboration with CPUC, engaging IOUs and other key stakeholders on data needs, continued stakeholder engagement process, equity considerations, etc.
- Scope and approach to inform reliable, effective, equitable implementation of strategic pruning.

Projected Ratepayer Benefits

7) Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

- **Energy Sector**. Provide direct support for state energy policy through research not adequately addressed by competitive or regulated entities, the benefits of which accrue to California citizens.
- **Market Connection**. This initiative provides insight into maintaining a reliable, stable market for natural gas ratepayers, with an emphasis on low-income ratepayers to help address equity considerations and promote participation in the early stages of gas system transition.
- **Energy and Cost Savings**. Operational analyses that support reliable operations will lead to cost savings by avoiding disruptions to service, which have direct impacts on natural gas ratepayers as well as indirect impacts – through natural gas power generation – on electricity ratepayers.
- **Equity Considerations:** The proposed analysis will focus on examination of natural gas decommissioning opportunities in low income and disadvantaged communities. The overarching goal is to inform an equitable and cost-effective gas system transition.

Questions to the Stakeholders

7) Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

- How can California's natural gas IOUs be effectively engaged in this study? What synergies with IOU priorities and planning could be leveraged to enhance the study?
- What other natural gas sector stakeholders (e.g., other state agencies, CCAs, community-based organizations, jurisdictions with electrification ordinances) could serve important roles in ensuring the study delivers useful results?
- What collaboration opportunities with related efforts could be most fruitful?

Presenter: Peter Chen

Transportation Research

Transportation Research Program Goals

Program Goals:

- Improve the energy efficiency and performance of gaseous fueled vehicles to reduce emissions and improve competitiveness.
- Increase the use of renewable gas to reduce GHG emissions from the transportation sector.
- Improve fueling infrastructure technology capabilities to promote the further adoption of low-carbon gaseous fueled vehicles.

Research Initiative #8

Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Background:

- Hydrogen has potential to serve as a zero-carbon energy resource across multiple sectors.
- Hydrogen fuel cell-electric vehicles (FCEVs) are an attractive zero-emission technology for heavy transport due to their high payload carrying capacity, fast refueling times, and long range.
- Hydrogen delivery and refueling costs make up around 80% of the cost of hydrogen at the dispenser.

Research Purpose & Description

8) Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Purpose

- Develop advanced hydrogen refueling station components and systems for high-capacity stations to support heavy transport applications transitioning to hydrogen fuel cell technology.

Research Description

- Promote infrastructure compatibility and standardization across multiple heavy-duty FCEV types including trucks, buses, and off-road vehicles.
- Increase station efficiency, reliability, capacity, and operational flexibility.
- Reduce station capital and operating costs to accelerate progress towards total cost of ownership parity with diesel.
- Possible research includes, but is not limited to developing and/or demonstrating:
  - High-capacity mobile refueler that can deliver and dispense hydrogen on-demand to heavy-duty FCEVs.
  - Innovative station designs with dedicated hydrogen production matched to fuel demand, integrated hydrogen use with other sectors to drive scale, and/or use of chemical hydrogen carriers to reduce distribution costs.
  - Improved hydrogen infrastructure components and interfacing technologies to reduce dispensing costs, increase fill rates to support larger vehicles, and improve reliability.

Projected Ratepayer Benefits

8) Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

- **Energy Sector.** Increase availability of low-cost hydrogen to help decarbonize difficult-to-abate end-uses including the natural gas system, industrial processes, and heavy transport.
- **Market Connection.** Enabling reliable, low-cost, and high-capacity hydrogen fueling infrastructure will improve the business case for heavy-duty FCEV adoption and station deployment in California.
- **Environmental Benefits.** Reduce air pollutant and greenhouse gas emissions by supporting a transition away from diesel engines to zero-emission hydrogen fuel cell technology.
- **Equity Considerations.** Reducing costs and expanding availability of hydrogen fueling infrastructure will improve air quality and zero-emission transportation accessibility, especially in under-resourced communities that are heavily impacted by these mobile sources.

Questions for the Stakeholders

8) Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

- Given the limited research funds, what specific barriers should be prioritized to reduce the cost of high-capacity hydrogen fueling infrastructure for heavy transport?
- What are some opportunities for this research to inform development of codes and standards to create replicable solutions?
- How can this research supplement private sector and other public investments in hydrogen fueling infrastructure research, demonstration, and deployment?

Feedback

The California Energy Commission would like to hear your thoughts on the proposed research initiatives.

Also, research suggestions can be provided to our Natural Gas Docket until ***February 08, 2021*** at: https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=16-PIER-01

These comments will be considered while developing the *FY 2021-22 Natural Gas Proposed Budget Report.*

Public Comments

Public Comments

- Please submit your question or comment in the **Question and Answers** window or raise your hand, and you will be called on to unmute yourself. *(Feature found under the Participants panel.)*
  - First, we will call on participants with raised hands for verbal comments/questions.
  - Next, we will turn to the Q&A window for typed comments/questions.
- Please remember to introduce yourself by stating your name and affiliation.
- Please keep questions or comments under 3 minutes to allow time for others.

Recap: Proposed Research Initiatives

Energy Efficiency

1) Hydrogen and natural gas blending for industrial end-use applications
2) Industrial Carbon Capture and Utilization

Natural Gas Infrastructure Safety & Integrity

3) Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages
4) Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

Renewable Energy and Advanced Generation

5) Developing and Demonstrating Hydrogen-Based Power Generation Systems

Energy-related Environmental Research

6) Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives
7) Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

Transportation

8) Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Projected Ratepayer Benefits

2) Industrial Carbon Capture and Utilization

Technology Potential.

- Improved efficiency and economics of carbon capture and utilization will promote wide adoption of these technologies
- Potential to enable use of Direct Air Capture technologies

Environmental Benefits.

- High potential for industrial GHG emissions reduction
- Carbon capture processes remove criteria air pollutants that are known to be harmful, including SO2, NOx and particulate matter because they need to be removed for technical reasons.

Equity Considerations. Many industrial facilities are in under-resourced communities, reductions in GHG emissions and criteria air pollutants and particulates would improve the air quality and reduce associated health affects in these communities.

APPENDIX B:
Comments from the Public, California Public Utilities Commission Staff, and the Disadvantaged Community Advisory Group with California Energy Commission Responses

The California Energy Commission (CEC) appreciates the comments and questions from stakeholders received during and in response to one workshop and two meetings on proposed initiatives for the FY 2021-22 Natural Gas Research and Development (R&D) Program. The workshop and meetings are summarized below. The comments and CEC staff responses for each are provided in the following sections.

- On January 29, 2021, CEC staff held a public workshop to present the proposed budget plan and received comments from stakeholders supporting the proposed initiatives and offering helpful input and perspective on specific research topics. CEC staff also received written public comments that have informed this proposed plan.
- On January 08, 2021, CEC staff held a coordination meeting with California Public Utilities Commission (CPUC) staff to present the proposed budget plan and received questions and comments from CPUC staff, offering helpful input and perspective on specific research topics, as well as suggesting potential research areas.
- On January 22, 2021, CEC staff attended a Disadvantaged Community Advisory Group (DACAG) meeting to present the proposed budget plan and received comments from stakeholders supporting the proposed initiatives and offering helpful input and perspective on specific research topics as they relate to under-resourced community needs.

Public Workshop Comments

The CEC appreciates the thoughtful and helpful comments from stakeholders received in response to CEC's January 29, 2021 staff workshop on proposed initiatives for the FY 2021-22 Natural Gas R&D Program. The workshop was attended by 117 people, not including the CEC panelists, and there were over two dozen attendee questions and comments during the workshop discussion. The CEC requested comments at the January 29, 2021 workshop and via notifications on the CEC website, listservs, and docket. A summary of the comments and CEC's responses is provided below. Please note that for brevity, footnotes included in public comments are not included in this summary.

Comment Received from: Cummins

Hello,

I attended last week's workshop to discuss proposed Natural Gas Research Initiatives for FY 2021-22 but had a question on FY 2020-21. During last year's workshop held on 01/21/2020 (https://www.energy.ca.gov/event/workshop/2020-01/staff-workshop-discuss-proposed-natural-gas-research-initiatives-fy-2020-21), the CEC presented a

Transportation Research Initiative related to Technology Integration and Demonstration of Hydrogen Fuel Cell Trucks and Buses. I was wondering if you could provide more information about this research initiative and in general about the NG Research Initiatives for FY 2020-21. I can't seem to find it on the CEC website.

Cummins has a strong interest in demonstration of heavy-duty hydrogen fuel cell trucks and buses, and we have several project concept ideas with prominent OEMs and customers that could be accelerated by such funding. I'd be happy to discuss with you further on this topic.

CEC Response:

The FY 2020-21 Budget Plan was approved by CPUC in November 2020. The "Technology Integration and Demonstration of Hydrogen Fuel Cell Trucks and Buses" initiative in the FY 2020-21 Budget Plan will be developed into a future funding opportunity to be released in Q2 2021. CPUC Resolution G-3571 and the approved FY 2020-21 Budget Plan can be found here: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M350/K143/350143395.PDF.

Comment Received From: T2M Global

Recommendations for R&D Topics for 2021-22:

1. Industrial Boilers "Natural Gas Fired: Use Hythane (10-20% Hydrogen in methane) for increasing efficiency and lowering emissions, using oxy-combustion or partial oxy-combustion.
2. Dual Fuel Electric and Gas Fired: Integrate natural gas fired industrial systems with excess power from renewables, such as solar and wind, and thus reduce natural gasuse and associated emissions.
3. Waste Heat Utilization from Natural Gas Systems: Develop and demonstrate hybrid systems to upgrade waste heat to higher value hydrogen and electricity with CO2 capture.
4. Hybrid Energy Cycles: Increase efficiency of industrial operations by developing hybrid energy cycles to reduce natural gas use and reduce emissions. An example will be engine and fuel cell hybrids with a variety of configurations.
5. Waste Feedstock Characterization: Characterize industrial wastes in terms of solid, liquid and gaseous as a feedstock for additional Green H2 and RNG - thereby reducing natural gas use and emissions.
6. Policy Input: Production of methane and hydrogen from solid biomass waste is classified as Green. However, production of hydrogen from industrial gaseous waste streams does not currently qualify as Green. Today, the hydrogen from these waste streams is underutilized or wasted. Please evaluate this emerging option for meeting CA State mandates.

Strategy Suggestion for CECs Natural Gas Program: Coordinate procurements with DOE-AMO, DOE-FE, etc.

CEC Response:

Staff appreciated the feedback from T2M Global. For the 2021-22 R&D Plan, due to funding limitations, CEC staff did not select Hydrogen and Natural Gas Blending for Industrial End-Use Applications as the industrial decarbonization initiative. We will investigate hydrogen

applications in our two initiatives on power generation and heavy-duty transportation applications and will consider additional research on hydrogen uses in future years. These are topics of interest for both the industrial and power generation research and for the most part, we have past research activities related to these topics, e.g. hybrid and fuel-flexible generation, waste heat applications, and waste feedstock utilization. A recent natural gas program solicitation (GFO-19-503 "Demonstrating Replicable, Innovative Large-Scale Heat Recovery Systems in the Industrial Sector") targeted waste heat reuse to reduce natural gas use and resulted in two agreements. Staff will keep these suggestions in mind for consideration in future research initiatives.

Comment Received From: PG&E

Pacific Gas and Electric Company (PG&E) appreciates the opportunity to provide feedback on the natural gas (NG) Research and Development (R&D) Program's proposed energy-related natural gas research initiatives for the 2021-22 fiscal year (FY).

PG&E supports the California Energy Commission's (CEC) effort to strategize on future research and their budget requests for the FY 2021-2022 natural gas R&D Program. PG&E commends the CEC for hosting a workshop on January 29, 2021, to seek feedback on the proposed natural gas research initiatives from utility representatives, researchers, members of the public, and other interested stakeholders. PG&E offers the following comments in seven of the proposed research initiatives to assist the CEC staff in developing their proposed NG research plan for FY 2021-22.

Research Initiative #1: Hydrogen and Natural Gas Blending for Industrial End-use Applications - Questions from the CEC:

CEC Question: Are there examples of industries that have successfully used hydrogen natural gas blends? Please provide links.

PG&E Response: PG&E and the other California gas utilities submitted application A.20-11-004 to the California Public Utilities Commission (CPUC) regarding a preliminary standard for hydrogen injection into the natural gas system. Chapter 3 of the testimony lists select global hydrogen blending projects where blends of hydrogen with natural gas were piloted in newly constructed gas pipeline systems.[1] The end users were varied and included residential, commercial and industrial customers.

CEC Response:

Staff appreciated the feedback from PG&E. For the 2021-22 R&D Plan, due to funding limitations, CEC staff did not select Hydrogen and Natural Gas Blending for Industrial End-Use Applications as the industrial decarbonization initiative. We will consider research on hydrogen blending for industrial applications in future years. We are aware of existing related research initiatives in hydrogen blending led by natural gas IOUs and others and are interested to collaborate on these topics.

[1] Link to Ch. 3 testimony: https://docs.cpuc.ca.gov/PublishedDocs/SupDoc/A2011004/3358/361624771.pdf

Research Initiative #2: Industrial Carbon Capture and Utilization

Questions from the CEC:

CEC Question: What are CO2 utilization technologies with highest market potential?

PG&E Response: The CO2 technologies with the highest potential are those that can convert CO2 using renewable electricity into methane that is already interchangeable with the existing natural gas system. This would be by a methanation process, whereby CO2 + H2 + renewable electricity produces CH4 + H2O.

CEC Question: What technologies have highest potential for on-site conversion of CO2 at the industrial facilities?

PG&E Response: The technologies with the highest potential for on-site conversion of CO2 at the industrial facilities are those installed alongside a biomethane production plant to take excess CO2 and renewable electricity to create methane that is already interchangeable with gas delivered by the existing natural gas system. For example, chemical and biological electrolysis technologies exist in various stages of development that can achieve this.

CEC Question: What industries in California have most potential for carbon capture and utilization?

PG&E Response: In California, the natural-gas-system-related industries with most potential for carbon capture and utilization are the gas reforming processes that have a large CO2 biproduct that can be captured and repurposed into valuable products, such as an additive to cement, carbon nanotubes, etc.

CEC Response:

Staff appreciated the feedback from PG&E. For the 2021-22 R&D Plan CEC staff selected Industrial Carbon Capture and Utilization as the industrial decarbonization initiative. The comments and recommendations will be incorporated and taken into consideration in the future solicitation on industrial carbon capture and utilization.

Research Initiative #4: Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement – Questions from the CEC:

CEC Question: What are the most desirable improvements on current technologies or practices for plastic pipelines?

PG&E Response: The most desirable improvements are non-destructive evaluation (NDE) fusion testing tools. The most desirable improvements for operational needs are technologies such as inline camera inspection.

CEC Question: Which components of plastic pipeline systems are more vulnerable to aging, degradation or risks, so that the safety enhancements can focus more on these components?

PG&E Response: Aside from the known issues with vintage plastics, PG&E recommends that the rubber goods in stab fittings be evaluated for remaining life and impacts.

CEC Question: Are there any additional research areas of interest to improve the overall integrity of plastic pipeline systems?

PG&E Response: PG&E recommends that a research area that improves the way to mark materials should be found to improve the overall integrity of plastic pipeline systems. The quality of the inks that are currently used in the industry on polyethylene (PE) needs major improvement.

CEC Response:

Staff appreciated the feedback from PG&E. The comments and recommendations will be incorporated and taken into consideration in future solicitation for plastic pipelines.

Research Initiative #5: Developing and Demonstrating Hydrogen-based Power Generation Systems

PGE offers the following general comments:

There is increased focus on hydrogen research. While hydrogen is a promising long-term solution to decarbonizing the natural gas system, an immediate solution is renewable natural gas (RNG).

Research is still needed to accelerate the efficient and cost-competitive production of RNG. For example, biomass is a good feedstock for creating RNG. There is also a large biomass resource potential in California, approximately 47 million bone dry tons. California doesn't yet have any plants that are converting wood-based biomass into RNG for injection into the natural gas grid. While advanced technology exists, there are financial barriers to getting such plants operational.

CEC Question: Are we effectively targeting research and technological development needs to support California's decarbonization goals and provide natural gas ratepayer benefits?

PG&E Response: PG&E agrees that power generation technologies that can effectively and efficiently use hydrogen as a fuel source are important. However, before that can happen, we need hydrogen generation technologies that are optimized for energy efficiency and are cost-effective at a large-scale. Earlier stage technologies need our support to advance and possibly become part of the state's portfolio of gas production technologies. When these technologies are more advanced and ready for a pilot demonstration, pairing with power generation downstream can occur. Consider emphasizing hydrogen production technology in addition to and separate from power generation in the cases of earlier stage development.

CEC Question: What are the technological and non-technological barriers to deploying hydrogen power generation that should be prioritized?

PG&E Response: One technological barrier is the compatibility of natural gas power generation with a blend of hydrogen and natural gas, with the possibility of converting to 100% hydrogen in the very long term. Hydrogen has different physical and chemical properties than natural gas.

CEC Question: What air quality considerations or benefits using blends should we be aware of?

PG&E Response: If using a blend of natural gas and hydrogen, combusted natural gas will still produce carbon dioxide and combusted hydrogen will simply produce water. Combusting a blend of natural gas and hydrogen for power generation purposes won't affect air quality from that perspective.

More research is needed to understand the leakage rates of hydrogen in a natural gas-hydrogen blend. Hydrogen may have higher leak rates in comparison with pure natural gas.

CEC Response:

Staff appreciate the feedback from PG&E. The comments and recommendations are valuable and will be considered in solicitation development under this proposed initiative and future research initiatives. Staff appreciate the emphasis on the need to accelerate the production of RNG and on hydrogen production technologies. Past research initiatives supported RNG and hydrogen production; for example, we had projects on capturing biogas from digesters for power generation and have two active projects that are developing technologies for creating RNG from woody feedstock. We also have an initiative on hydrogen production from last year's (FY 2020-21) Natural Gas R&D Program budget plan. The comments on the barriers and air quality considerations are integrated into the proposed initiative and will be considered when developing the solicitation.

Research Initiative #6: Quantify Exposures to Indoor Pollutants in MF Homes Cook with NG or Alternatives

CEC Question: How should the study population be defined? (e.g., multi-family households that include residents vulnerable to air pollution exposures, low-income single-family homes, etc.)?

PG&E Response: According to a study by the University of California, Los Angeles, "Environmental health burdens associated with gas appliance use can disproportionately affect low-income individuals, who are often renters with less control over appliance installation and maintenance, and typically living in smaller units, which can result in elevated pollutant concentrations." Based on this, PG&E recommends that the CEC prioritizes low-income communities in any research initiative related to indoor air quality and cook stoves.[2]

PGE offers the following general comments:

PG&E strongly supports investments in objective research that will contribute to understanding the indoor air quality (IAQ) impacts of cooking and to identify opportunities to mitigate cooking pollutants in new and existing buildings.

PG&E also supports investments into research that identifies strategies to ensure dwellings of all sizes have the proper kitchen ventilation (e.g., vented range hoods, vented downdraft exhaust, continuous kitchen exhaust, compartmentalization) needed to mitigate the negative impacts of cooking appliances on IAQ.

Decades of research has determined that the heating and cooking of food by any method releases ultrafine and fine particles such as particulate matter (PM) 2.5 micrometers or smaller

[2] "Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California." UCLA Fielding School of Public Health, Apr 2020: https://coeh.ph.ucla.edu/effects-residential-gas-appliances-indoor-and-outdoor-air-quality-and-public-health-california

as well as other irritants such as formaldehyde, acetaldehyde, acrolein and polycyclic aromatic hydrocarbons. When using natural gas, additional pollutants are released that negatively impact the IAQ, in particular nitrogen oxides (NOx) and carbon monoxide (CO).

PG&E is proud to support our customers' energy needs and provide electricity and natural gas for use in a variety of applications, including cooking.

CEC Response:

Staff appreciate the feedback from PG&E. Staff concur with the need to prioritize homes occupied by low-income residents in the proposed research, as such homes are typically smaller (with less volume of air for dilution of health-damaging pollutants) and residents may be more vulnerable (given that socio-economic status is a strong predictor of health). Staff have explicitly worked this consideration into the proposed initiative.

Research Initiative #7: Location-specific Analysis of Decommissioning to Support Long-term Gas Planning

PGE offers the following general comments:

PG&E respectfully refers the CEC to its comments submitted on December 31, 2020, on the "Strategic Pathways and Analytics for Tactical Decommissioning of Portions of Natural Gas Infrastructure" (GFO-20-503) solicitation.[3] Though submitted in response to one solicitation, the comments capture PG&E's perspective on how the CEC can achieve the greatest impact from research projects focused on "tactical decommissioning" and targeted building electrification.[4]

While more detail is provided in the prior comments, PG&E reiterates that its overarching recommendation is to build on existing expertise and experience, rather than duplicating efforts. Accomplishing this goal includes:

Focusing resources on untested "use cases" and known gaps in order to achieve scale: on dozens of occasions, PG&E has pursued targeted electrification as an alternative to an upcoming gas system project—and PG&E will continue to do so. There are few opportunities that are cost-effective and feasible for PG&E to fund, however. Most of the work (and cost) of maintaining a safe gas system cannot be avoided with PG&E action and funding at this time. CEC research is needed to develop a pathway for this yet un-addressed majority of the system. The opportunities that PG&E can (and does) pursue are simply not enough to achieve California greenhouse gas (GHG) emissions reduction goals; a path to scale outside of these "unicorn" situations is crucial.

Leveraging utility tools, analysis, and expertise: PG&E gas system engineers have deep knowledge of the operations of each gas system, and possess the training, tools, and access to confidential data to identify risks that require attention and scope the work needed to

[3] Solicitation GFO-20-503, Strategic Pathways and Analytics for Tactical Decommissioning of Portions of Natural gas Infrastructure https://www.energy.ca.gov/event/funding-workshop/2020-12/pre-application-workshop-gfo-20-503-strategic-pathways-and-analytics

[4] PG&E's comment letter addressed to Tonya Heron and Qing Tian on December 31, 2020, in response to the GFO-20-503 solicitation.

address those risks. PG&E experts can perform hydraulic modeling to understand impacts of changes on the system and conduct many other types of analysis that would be needed to inform "tactical decommissioning" plans and strategies. PG&E's historical expertise in this area can provide critical input to complement the strengths of other entities.

Driving problem-solving to the most critical challenges: from its successes (and failures) pursuing electrification alternatives to the gas system projects, PG&E has found that "tactical decommissioning" is most persistently and significantly limited by existing regulations, policy, and funding mechanisms. Lack of locations is not the obstacle to targeted electrification at scale; PG&E can identify many locations where a gas project is planned in the nearer-term, or even areas where "tactical decommissioning" might be feasible or beneficial in the longer-term. With no funding nor regulatory path to pursue targeted electrification in almost all cases, however, there is little value to identifying locations. Research and innovation are needed to address these most problematic hurdles—which exist in every location outside of those very limited circumstances that PG&E already pursues.

CEC Response:

Thank you for these extensive and helpful comments. While staff recognize PG&E's assertion that regulations, policy, and funding mechanisms pose the most daunting obstacles to implementation of electrification, staff assert that publicly funded R&D regarding infrastructure and operations at a statewide or regional scale are critical complements to analyses of the aforementioned challenges. Specifically, publicly-funded research—including research focusing on physical infrastructure and operational issues—will support the state taking an active role in charting a strategic path toward safe, equitable, cost-effective decommissioning to meet the California's energy and climate goals. Staff will continue to work with and learn from IOUs to focus and refine research efforts related to decommissioning.

Research Initiative #8: Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

PGE offers the following general comments:

PG&E supports promoting infrastructure compatibility and standardization across the various Fuel Cell Electric Vehicle (FCEV) types and opportunities to demonstrate innovative station designs that co-locate heavy-duty Compressed Natural Gas (CNG) fueling with FCEV fueling infrastructure to support California's goals toward decarbonizing the transportation sector.

PG&E appreciates the time and effort that the CEC took to organize the workshop and prepare the Public Interest Natural Gas R&D Program's proposed energy-related natural gas research initiatives for the 2021-22 fiscal year. PG&E also appreciates the opportunity to comment on the development of these important research initiatives. Please do not hesitate to contact me if you have any questions.

CEC Response:

Co-locating hydrogen refueling stations with other alternative fuel types including CNG for heavy-duty vehicles to reduce costs fits within the "Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport" initiative. The differing physical properties of hydrogen and natural gas need to be considered for any innovative station designs involving shared equipment across the two fuels.

Comment Received From: Calpine Corporation

Calpine Corporation (hereinafter, "Calpine") offers the following comments regarding the Workshop on Proposed Natural Gas Research Initiatives (NGRI) held January 29, 2021. Calpine is one of California's largest energy providers and the State's leader in renewable energy and combined heat and power production. Calpine is a long-time supporter of federal and State efforts to control greenhouse gas emissions (GHG) and an advocate for achieving California's climate goals. In addition, Calpine is actively engaged in developing battery storage and carbon capture utilization and storage (CCUS) projects in California.

Calpine currently has invested and is facilitating two CCUS pilot projects at one of its operating plant in the Pittsburg area. The first project has a unique technology that captures carbon dioxide and coats aggregate, which can then be sold in the concrete market as light weight aggregate for construction material. The second project is using a DOE grant to test a transformational carbon capture solvent and operating system.

We realize that the NGRI workshop focused on CCUS for the industrial sector, but Calpine believes that innovation and technology development in both the industrial and power generation sectors are necessary to make CCUS a viable technology. Because both sectors could leverage some of the same infrastructure, attention to both sectors could significantly facilitate deployment in either sector. For example, development of CCUS "hubs" that could potentially collect carbon dioxide from both power generation and industrial sources for ultimate storage in geological formations would provide the benefit of scale and allow projects to proceed that would otherwise not be cost effective. In addition, specific capture technologies may be applicable to multiple sectors. In addition, CCUS for power generation has important benefits for the power sector that the CEC already has recognized in its SB100 modeling. This modeling identified the important role of zero-carbon firm generation. CCUS for power generation could fulfill this role.

Consequently, the CEC should consider funding research in CCUS regardless of sector. Additional funding to assist companies in development of capture technologies that can benefit both the industrial and power generation sector would accelerate technology development and commercial installations. For example, pre-FEED and FEED studies that must be completed prior to construction can cost upwards of ten million dollars and take more than a year to complete. Actual construction of a project could cost several hundred million dollars, which will be a significant investment for any company.

In addition to technology development, another significant barrier to deployment of CCUS is the uncertain permitting pathway all three phases of a CCUS project, including the capture unit, the physical means of transporting captured gas to the sequestration site, and the permanent geological storage. All three of these phases require the involvement and oversight of several state and federal agencies, creating significant permitting risk for a project. Timely completion of each phase is critical to having a viable project. Permit streamlining and certainty in the permitting path are critical for companies to make an investment in CCUS. State support for an expedited and streamlined permitting process would accelerate development of CCUS projects.

Calpine appreciates the opportunity to comment on this workshop and urges the CEC to expand its Natural Gas Research Initiatives to include natural gas power generation facilities. CCUS can serve a critical role in decarbonization of both the electrical and industrial sectors

and help achieve California's goals in a cost-effective manner. We look forward to continuing to work with you on these important issues.

CEC Response:

Staff appreciated the feedback from Calpine and sharing the information on the two CCUS pilot facilities. For the FY20-21 budget plan, we are focusing on the industrial sector given funding limitations. We anticipate that technologies developed for CCU in the industrial sector would be applicable to other sectors as well. We will track research on CCUS for power generation and may consider this research area in a future budget plan.

Comment Received From: SoCalGas

Dear Staff:

I write on behalf of Southern California Gas Company (SoCalGas) in response to the California Energy Commission's (CEC's) Staff Workshop to Discuss Proposed Natural Gas Research Initiatives for fiscal year (FY) 2021-22 held on January 29, 2021. SoCalGas appreciates the opportunity to comment on the broad research initiatives outlined by CEC and provide responses to the questions raised during the workshop. SoCalGas' Research Development and Demonstration (RD&D) portfolio has a number of completed or on-going projects in the research areas outlined by CEC. To expand CEC's awareness of our projects, we have provided a few examples below. We also invite CEC staff and other stakeholders to review our 2019 RD&D Annual Report[5] for additional information on SoCalGas's RD&D program and our research projects.

Energy Efficiency

Research Initiative#1: Hydrogen and Natural Gas Blending for Industrial End-use Applications

Current SoCalGas RD&D Projects that could inform development of this initiative:

- UTD High Hydrogen Burner for Large Commercial and Industrial Applications: Develop a commercial/industrial scale fuel flexible burner that is highly efficient and economical utilizing high blends of hydrogen (up to 60%) while minimizing emissions.
- UTD Field Validation of Gas Quality Sensor (GQS) - Phase 3: Hydrogen Sensor: Conduct calibration tests on the GQS with an add-on hydrogen detector so the GQS can be used to monitor natural gas containing hydrogen.
- UTD Integrating RE-Derived Hydrogen into Industrial Operations: Assess and evaluate hydrogen production pathway from renewable energy sources and the direct integration of produced hydrogen into industrial operations.
- UTD Ribbon Burner Performance Evaluation with Gases Containing Hydrogen: Evaluate the ribbon burner performance when operating with hydrogen and natural gas/hydrogen mixtures in controlled laboratory environment.

[5] https://www.socalgas.com/sites/default/files/2020-06/2019%20SoCalGas%20RDD%20Annual%20Report_remediated.pdf

- SMP Low-Cost Carbon Neutral Natural Gas to Hydrogen Production: Evaluate hydrogen production processes from natural gas and perform lab scale testing of the two best technologies.
- SMP Ceramic Matrix Composite Materials for High Hydrogen Combustion End Use: Develop and test a low-cost improved life composite material for high hydrogen applications.
- EAC Testing of Hydrogen/NG Blend Impact on Appliances – Phase 2: Develop a tool that takes gas supply composition data (natural gas, hydrogen, and biogas blends) and generates graphical depictions of the performance characteristic for appliances
- UCI Solid Oxide Electrolysis Cells (SOEC) for Green Steel Production Demonstration: Study, demonstrate, and optimize an integrated high temperature process for the direct reduction of iron with hydrogen produced from a SOEC system.

SoCalGas responses to CEC questions for the stakeholders:

CEC Question 1: What should be the targeted industrial sectors and processes? Why?

- Energy Futures Initiative (EFI) released a report on pathways for deep decarbonization in California.[6] The report recommends focusing on areas with low electrification potential: petroleum refining & hydrogen production; pulp & paper; stone, clay, stone, clay, glass &cement; chemical & allied products; food products.

CEC Question 2: Are there sectors or process applications to avoid? Why?

SocCalGas Response: Further research and discussions with customers in a number of sectors will be needed to addressthe concerns raised by the following sectors:

- Metals customers (e.g. heat treating, steel forging, aluminum melting), glass and ceramics manufacturers, hydrogen production/refineries:
- Metals industry: concerns about hydrogen effects to heat treating atmosphere, controls, processing; for steel products that have direct contact with the fuel, hydrogen embrittlement may be a concern when using hydrogen blends; concern for hydrogen leading to increased moisture content and oxide formation and their impact to product quality
- Glass and ceramics manufacturers: concern for increased NOx, lower radiative heat transfer, and increased moisture content
- Hydrogen production/refineries: concern that existing piping and measurement equipment are not compatible with hydrogen blends

CEC Question 3: What are specific research needs in the area of natural gas and hydrogen blends in industrial end-use applications?

SocCalGas Response: Impacts to existing equipment (e.g. pipes, orifice plates, valves, burners), operations (e.g. heat uprates, burning temperature, safety, process controls), NOx emissions, quality and safety of molten metal products; hydrogen threshold for existing

[6] https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/5ced6fc515fcc0b190b60cd2/1559064542876/EFI_CA_Decarbonization_Full.pdf

equipment and processes and/or potential retrofits to accommodate hydrogen blends; determine if customers need to reapply for air permits

CEC Question 4: What are non-technological barriers that hinder the use of hydrogen and natural gas blends?

SocCalGas Response:

- Potential fuel cost increases and additional permitting/certification for using a different fuel
- Public awareness, social acceptance, and public perception
- Market conditioning
- Bridge the gap between demonstration stage and commercialization
- Knowledge dissemination not only to the experts, but also value to society so that they understand the technology and their advantages; value proposition for end-users
- More support from regulatory stakeholders on large-scale efforts for expansion on hydrogen infrastructure and distribution network
- Incentives or mandates to support development and manufacturing; supply chain development

CEC Question 5: Are there examples of industries that have successfully used hydrogen natural gas blends? Please provide links.

SocCalGas Response:

- AMF Bakery Systems has developed an industrial oven that can run on H2 blends up to 100%: https://bakeryinfo.co.uk/equipment/hydrogen-tunnel-oven-launched-by-amf-bakery-systems/646187.article#:~:text=AMF%20Bakery%20Systems%20unveils%20hydrogen%20tunnel%20oven&text=Its%20Multibake%20Vita%20Tunnel%20Oven,%2C%20hydrogen%20fuelled%20tunnel%20oven%E2%80%9D.
- UK: Baxi Heating and Worcester Bosch have installed Hydrogen Boilers at 'HyStreet': https://fuelcellsworks.com/news/uk-baxi-heating-and-worcester-bosch-have-installed-hydrogen-boilers-at-hystreet/.
- Scottish Homes to be the first in the world to use 100% green hydrogen: https://www.theguardian.com/environment/2020/nov/30/scottish-green-hydrogen-fife.
- ATCO to build Alberta's first hydrogen blending project with Emission Reductions Alberta's (ERA) support: https://www.prnewswire.com/news-releases/atco-to-build-albertas-first-hydrogen-blending-project-with-era-support-301096658.html.
- Globally, hotspots for hydrogen innovations project include Saudi Arabia, Denmark, Austria, New Zealand, Australia, Singapore, Germany, Chile, Spain, China, and Japan.

CEC Question 6: What air quality considerations for using blends should we be aware of?

SocCalGas Response: See response to question #3.

CEC Response:

Staff appreciated the feedback from SoCalGas and for sharing related research projects. For the 2021-22 R&D Plan, due to funding limitations, CEC staff did not select Hydrogen and Natural Gas Blending for Industrial End-Use Applications as the industrial decarbonization initiative. We will continue to track research efforts in this area and will consider research on hydrogen blending for industrial applications in future years.

Research Initiative #2: Industrial Carbon Capture and Utilization

SoCalGas responses to CEC questions for the stakeholders:

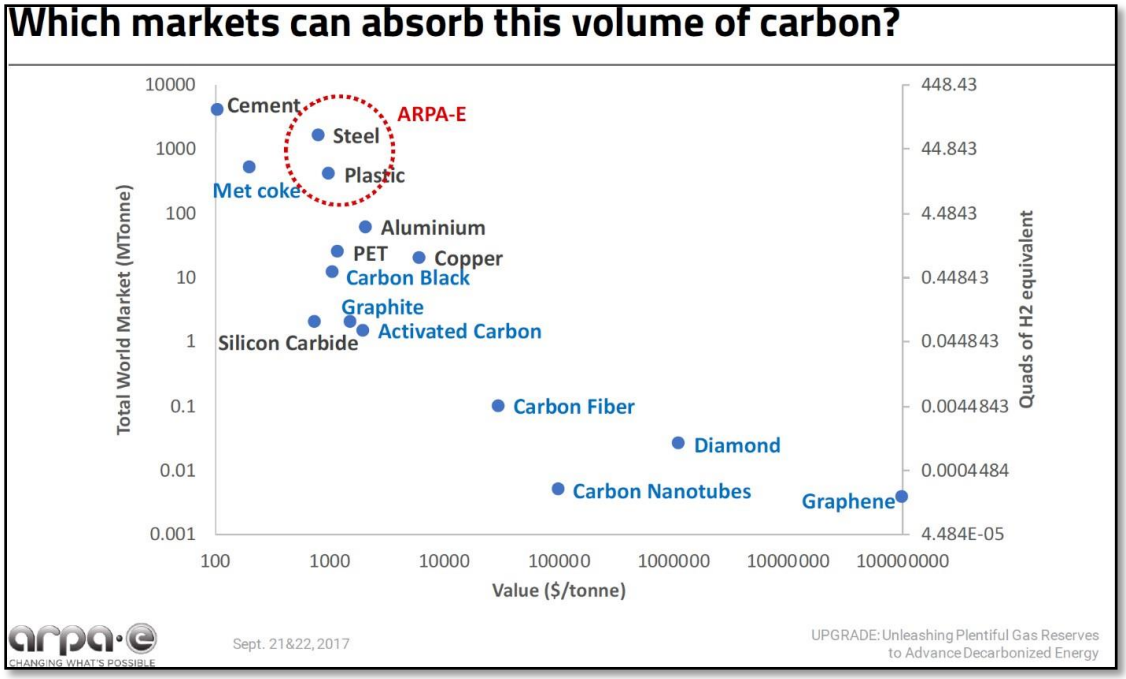
CEC Question 1: What are CO_2 utilization technologies with highest market potential?

SocCalGas Response: Utilization of CO2 is a function of scale and cost. A 2018 report from National Academy of Sciences (https://www.nap.edu/catalog/25232/gaseous-carbon-waste-streams-utilization-status- and-research-needs) and a 2019 paper in Nature, (Nature 575, 87–97 (2019). https://doi.org/10.1038/s41586-019-1681-6) identify several promising technology CO2 utilization pathways. These pathways include:

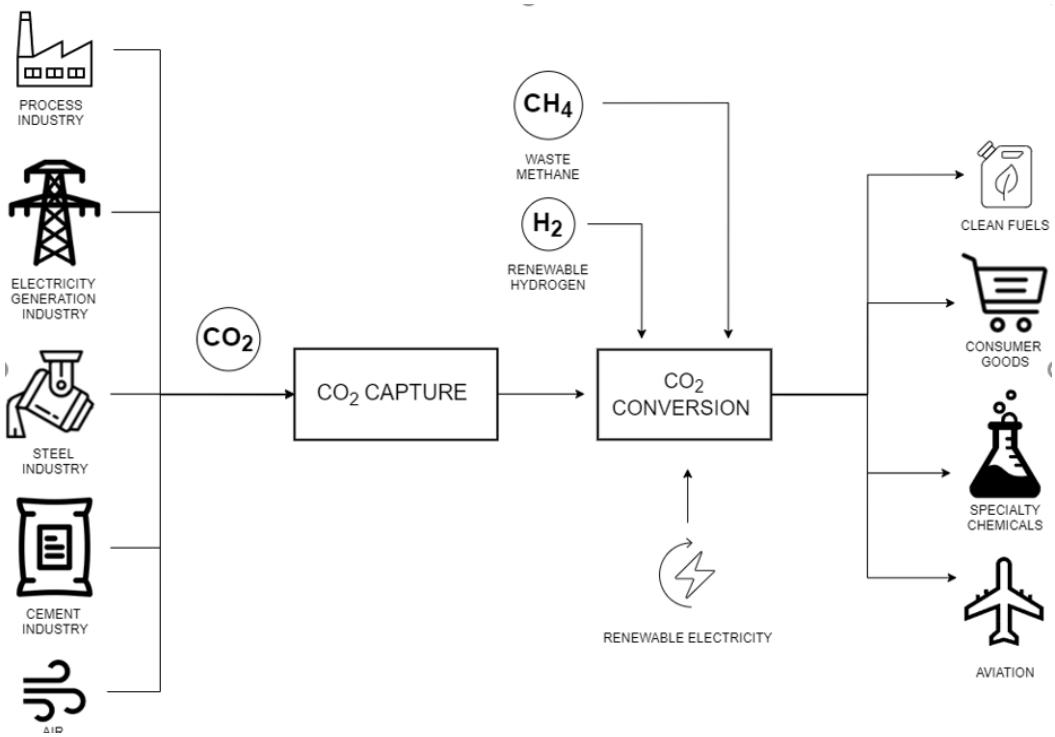
- Conversion into construction materials (concrete, aggregates, etc.)
- Biochemical conversion to make hydrocarbons (RNG, ethanol, butanol, etc.)
- Thermochemical conversion to produce fuels (methanol, Fischer Tropsch, DME, etc.) and chemicals.
- Conversion into specialty polymers
- Electrochemical conversion to products (CO, ethanol, formic acid, etc.) For example: Researchers discover effective pathway to convert carbon dioxide into ethylene (phys.org)

Both fuel production for a circular economy and building materials (see illustration below) are attractive due to the size of their markets.

Construction materials have gained traction as evidenced by strong funding for companies like Solidia, CarbonCure, CO2NCRETE, etc., who have developed technologies for utilization of CO2 captured from anthropogenic sources. Other CO2 conversion technologies for chemicals may be limited initially due to the massive quantities of CO2 that must be converted to make a difference in atmospheric temperature forcing and, if converted into any given commercial chemical, they would overwhelm existing markets.



Long-term, if CO_2-based products can replace petroleum feedstocks using renewable energy, there could generate a strong market pull. A conceptual design is provided below.

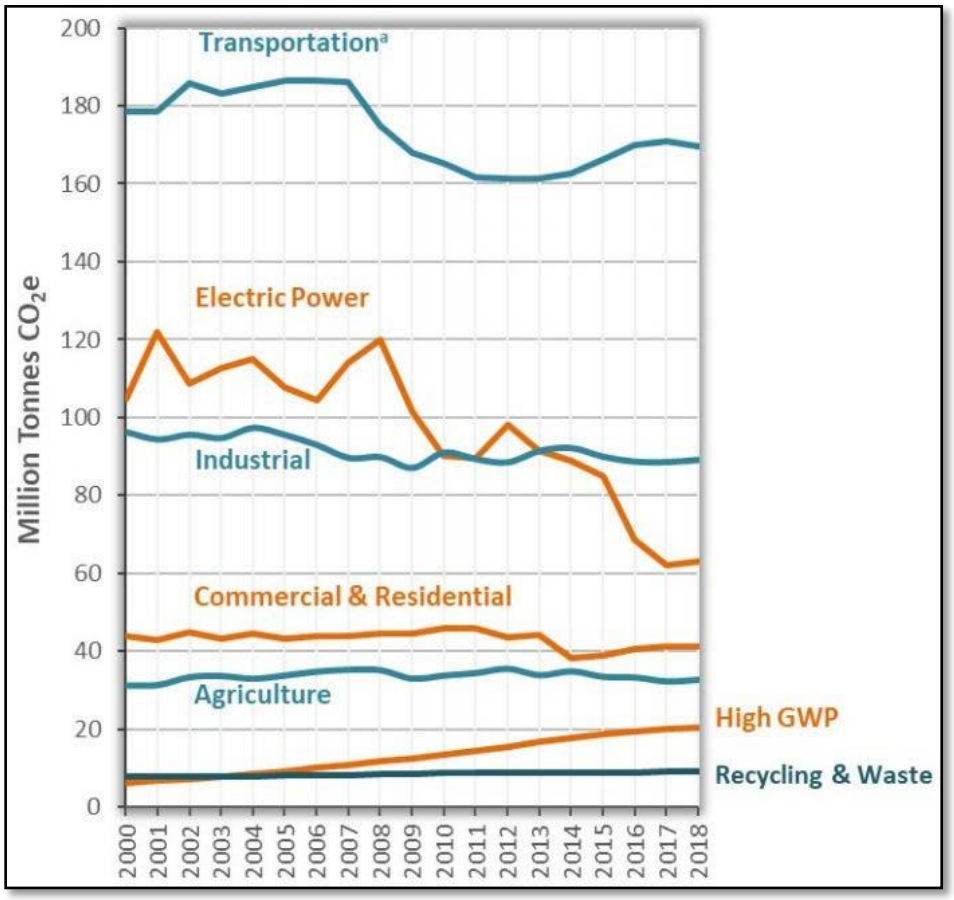


CEC Question 2: What technologies have highest potential for on-site conversion of CO2 at the industrial facilities?

SocCalGas Response: Any CO_2 conversion requires electrons in the form of hydrogen or electricity inputs. With that in mind, on-site CO_2 conversion at an industrial facility with the highest potential may be fuels suchas methanol, methane, gasoline, etc.

CEC Question 3: What are specific research needs for industrial carbon capture and utilization in California?

SocCalGas Response: Since significant stationary CO_2 emissions in California are produced in power generation and industrial process heat, there is a need to develop and demonstrate cheaper carbon capture systems for flue gas containing <6% CO_2. Traditional amine-based solvents for these low concentrations of CO_2 have not yet proved to be cost-effective. Some of the technologies being developed for direct air capture could be extended for the flue gas streams generated by natural gas combustion. One example could be electrochemical swing adsorption where renewable electricity could be used for sorbent regeneration.



Source: Greenhouse Gas Inventory Trends (ca.gov)

For high concentrations of CO_2 from industrial sources like cement production, steel production, hydrogen from steam methane reformers, existing/emerging technologies can be used effectively. However, research is needed to support the demonstration of these technologies integrated with various processes and at a variety of facility locations.

CEC Question 4: What are non-technological barriers that hinder adoption of carbon capture and utilization?

SocCalGas Response: Lack of regulatory framework and carbon price is a major barrier. Also, there is state sanctioned CO2 storage facilities nor CO_2 pipeline infrastructure to transport captured CO_2 to designated CO_2 sinks.

CEC Question 5: What industries in California have most potential for carbon capture and utilization?

SocCalGas Response:

- Refineries, bioethanol and chemical processing plants
- Landfills and wastewater treatment plants
- Dairies and feedlots

CEC Question 6: What are examples of industrial carbon capture and utilization that would be helpful in our research?

SocCalGas Response:

- Methane pyrolysis (co-production of hydrogen and solid industrial carbon) as a substitute for steam methane reforming at petroleum refineries
- Reactive CO2 capture and use.
    - Integrated CO2 Capture and Conversion to Methanol (ICCCM) -- ORNL
    - Integrated CO2 Capture and Conversion to ethanol (ICCCE) – PNNL

CEC Question 7: What are anticipated co-benefits of carbon capture on air quality (criteria air pollutants and particulates)? Links to supporting literature.

SocCalGas Response:

- Carbon sequestration and biodiversity co-benefits of preserving forests in the western United States - https://esajournals.onlinelibrary.wiley.com/doi/10.1002/eap.2039
- Environmental co-benefits and adverse side-effects of alternative power sector decarbonization strategies - https://www.nature.com/articles/s41467-019-13067-8
- Co-Benefits of Carbon Offset Projects: Information for Carbon Offset Procurement - https://secondnature.org/wp-content/uploads/Co-Benefits-Document-Rev5.pdf
    - Co-benefits of greenhouse gas mitigation: a review and classification by type, mitigation sector, and geography - https://iopscience.iop.org/article/10.1088/1748- 9326/aa98d2/meta

CEC Response:

Staff appreciated the detailed feedback from SoCalGas. For the 2021-22 R&D Plan CEC staff selected Industrial Carbon Capture and Utilization as the industrial decarbonization initiative. The comments and recommendations will be incorporated and taken into consideration in the future solicitation on industrial carbon capture and utilization.

Natural Gas Infrastructure Safety and Integrity

Research Initiative #3: Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages

Current SoCalGas RD&D Projects that could inform development of this initiative are:

- 3vG Satellite InSAR Monitoring, Pilot Project (SoCalGas)
- Airborne Automated Threat Detection System-Monitoring and Surveillance of Imminent Threats Through Remote Sensing (PRCI ROW-3-1&A)
- Enhancing Strain Capacity of Pipelines Subject to Geohazards (PRCI SBD-1-6)
- Fault Displacement Hazard Initiative (UCLA)

- Fiber Optics Pipeline Integrity Monitoring System at a Creek Bed (SoCalGas)
- Geohazard Land Management JIP (INGAA)
- InSAR Monitoring of Pipeline Geohazards in Vegetated and Very Large Non-Vegetated Areas (PRCI GHZ-2-03&A)
- Guidance on the Excavation and Backfill Procedures in Areas of Geohazards and High Axial Stresses and Strains (PRCI SBD-1-5)
- Modernize the Assessment of Pipeline Water Crossings (PRCI ENV-4-1A)
- Modernize the River X Software (PRCI ENV-4-1)
- Optimal Approach to Cost Effective, Multi-source, Satellite Surveillance of River Crossings, Slope Movements and Land Use Threats to Buried Pipelines (PRCI GHZ-2-02)
- Post Fire Debris Flow Studies (SoCalGas)
- Seismic Risk Assessment and Management of Natural Gas Storage and Pipeline Structure (CEC GFO-18-502)(Group 1) – (Slate/Berkeley & UCLA)

SoCalGas responses to CEC questions for the stakeholders:

CEC Question 1: What would be the most suitable technologies for monitoring pipelines and ground movement?

SocCalGas Response:

- Fiber optics-based pipeline monitoring for new or replacement pipelines. Vibration sensors and strain gauges for existing lines. We are interested to see if there are any projects that have successfully retrofitted existing lines safely while keeping them in service.
- Satellite monitoring, drone, and LIDAR.
- Areas where research would be beneficial:
    - With steep hills or mountains, the satellite cannot pick up the information correctly. It is called shadow effect. If CEC can look into the effect of this in State of California based on our unique geography it would be very beneficial.
    - Another research project is to use satellite technology that can look through vegetated areas to measure ground movement. The current satellite technologies do not have this capacity.

CEC Question 2: What would be the best approach to integrate monitoring data into utility integrity management systems?

SocCalGas Response:

- Overlaying the data onto the GIS system, so the impacted areas can be identified and monitored.
- Universal dashboard with GIS related data overlaid on top of dig alert and current construction activities may it be 3rd party or internal construction.

CEC Question 3: What are important project considerations in the R&D stage to eventually allow for commercialization and incorporation into utility operations?

SocCalGas Response: Cost. Impact to current processes. Operations and maintenance burden. Interoperability.

CEC Response:

Staff appreciated the detailed feedback from SoCalGas. The comments and recommendations will be incorporated and taken into consideration in future solicitation for initiative #3.

Research Initiative #4: Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

Current SoCalGas RD&D Projects active in 2020 that could inform development of this initiative are: (*Projects in italics were new in 2020*).

- Aldyl-A Mains Failure Rate Analysis (SoCalGas)
- Alternative Caps for PE Service Tees (OTD 5.16.b)
- Applying Heat to Steel Near PE (OTD 5.19.s)
- Composite Repair Wrap for PE - Phase 2 (OTD 2.14.a.2)
- Eclipse Scientific Red/Green Light Tool for NDE of PE Pipe Butt Fusion Joints - Phase 1-a (NYSEARCH M2019-010)
- Enhance Risk Assessment Tools for Decision Making (OTD 9.20.a)
- JIP PE Systems Research Program - Phases 1 and 2 (OTD 5.16.r, 5.16.r.2)
- Material - Suppliers Quality Assurance Program (OTD 5.17.g)
- Modeling and Assessing PE Assets with 3D Scanning Technology
- *NJIT Advanced Terahertz (THz) Imaging & Spectroscopy for Non-Destructive Evaluation of Polyethylene Pipes (NYSEARCH M2018-009 PhII)*
- PE Leak Growth Rate from Slow Crack Growth Research Project (OTD 7.15.c)
- Risk Profile for Aldyl-A Piping System - Phase 3 (OTD 2.13.d.3)
- Rounding Clamp Evaluation (SoCalGas)
- Small PE Diameter Squeeze-Off - Phase 2 (OTD 2.14.c.2)
- Standard Library of PE Joint Samples with Embedded Defects for NDE Tool Validation -Phase I-a (NYSEARCH M2019-009)
- Subsurface Multi-Utility Asset Location Detection (OTD 5.20.a)
- *Validation of NDT Technology for PE Pipe (OTD 5.20.p)*
- *Xray and Terahertz Development for NDE of PE Pipe by Iowa State University (NYSEARCH M2019-007 Phase II)*

SoCalGas responses to CEC questions for the stakeholders:

CEC Question 1: What are the most desirable improvements on current technologies or practices for plastic pipelines?

- Current technologies for plastic pipelines should be evaluated against the pipe and fitting materials installed in a system along with operating practices of individual utilities. The performance of different plastic pipe materials, construction practices, and operations and maintenance practices can vary widely between utilities. System performance should be assessed based on leak rates and severity of leaks for system pipeline categories. Pipeline categories may need to be stratified by service pressure, average service temperature, and the vintage or types of pipe and fittings installed.

CEC Question 2: Which components of plastic pipeline systems are more vulnerable to aging, degradation or risks, so that the safety enhancements can focus more on these components?

SocCalGas Response: The variables referenced in answer to question #1 will need to be considered. The prevalent vintages of pipe, types of fittings installed and root cause of plastic pipeline system failures will vary widely by utility. Current integrity management programs are designed to identify system threats and systemic issues. With the objective of improving system integrity, it may be necessary to determine whether development of plastic pipeline repair technology is the most important area of focus for California utilities.

CEC Question 3: Are there any additional research areas of interest to improve the overall integrity of plastic pipeline systems?

SocCalGas Response: Locations of leaks on plastic pipelines are highly randomized due to the number and complexity of contributing variables involved. On this basis we suggest the following areas where SoCalGas and SDG&E have interest in additional research:

- Locating Underground Plastic Pipe: A significant amount of vintage plastic pipe is difficult to locate and mark due to long-standing challenges such as original installation without tracer/locating wire, original installations using bare wire, or cases of faulty connections and third-party wire damage. Evaluating non-intrusive plastic pipe locating technologies to effectively locate plastic may prove beneficial especially in reduction of excavation damages locating leaks.
- Determine Temporal Growth Rate of the Leak Flow Rate in Plastic Piping Systems due to slow crack growth: a great deal of research has been conducted to determine how long plastic pipe will last until leaks develop due to the "slow crack growth" failure mechanism of polyethylene. However, the above referenced OTD project (OTD 7.15.c) is the first study of the rate at which the leak flow rate grows once manifested, and more research is needed. Non-hazardous leaks are currently granted longer repair periods with reevaluation every 6 months. Although great strides and effort is being made to replace vintage PE pipe systems, California utilities still operate a significant amount of Aldyl-A PE pipe. It would be beneficial to assess if once identified, small non-hazardous leaks have a high probability to remain non-hazardous for the period between detection and repair. In addition, changes in gas composition such as natural gas/hydrogen blends in the distribution system and its effects in leak flow rate growth could also be studied.

CEC Response:

Staff appreciated the detailed feedback from SoCalGas. The comments and recommendations will be incorporated and taken into consideration in future solicitation for plastic pipelines.

Renewable Energy & Advanced Generation Program

Research Initiative #5: Developing and Demonstrating Hydrogen-Based Power Generation Systems

Current SoCalGas RD&D Projects that could inform development of this initiative:

- UCI Fuel Flexible Microturbine Generator Development – The goal of this project is to increase the hydrogen blending limit in a Capstone C-60 microturbine.

- UCI Effect of Hydrogen Addition into Natural Gas on SCR of NOx Lab Testing - The goal of this project is to determine the effects hydrogen containing fuel has on SCR catalysts, found downstream from gas turbines.
- UCI Flex Fuel Rotary Engine MicroCHP - The goal of this project is to determine the performance impacts hydrogen blending has on the Mazda Rotary Engine mCHP developed by UCI in a previous CEC funded project.
- UCI Hydrogen Energy Storage Integration with Dispatchable Power Generation Study - This DOE funded project will begin designing an integrated hydrogen generation and storage system to be added to UCI's campus microgrid. The hydrogen will be blended with natural gas to fuel UCI's existing 13 MW gas turbine.

SoCalGas responses to CEC questions for the stakeholders:

CEC Question 1: Are we effectively targeting research and technological development needs to support California's decarbonization goals and provide natural gas ratepayer benefits?

SocCalGas Response: There is room for interpretation, but this research area seems focused on Hydrogen blending in traditional combustion-based generation technologies. It would be extremely valuable to pursue fuel cell demonstration projects, which could have an immediate impact on air quality while helping to improve affordability. If paired with RNG or H2, even SOFC technology could have significant impacts on GHG emissions, in addition to the NOx reduction.

There is still a valuable R&D taking place outside of the hydrogen world, developing technologies that can achieve low GHG and NOx with natural and/or renewable gas. Excluding these projects might impact short term benefit opportunities.

CEC Question 2: What are the technological and non-technological barriers to deploying hydrogen power generation that should be prioritized?

SocCalGas Response:

- Blending thresholds for combustion technologies need to be established and warranted by manufacturers.
- Affordability and public awareness is the biggest hurdle for fuel cells. Fuel cells need regulatory support and/or massive market adoption to drive down costs. Technologically, they can accept up to 50% H2 immediately in some SOFCs, or 100% H2 in PEMFC's.

CEC Question 3: Do you have suggestions for research and development needed to improve the technical and economic aspects of the proposed technologies?

SocCalGas Response: It would be valuable to determine which engines and turbines are most ubiquitous in California and work with the manufacturers to determine H2 blend thresholds for existing equipment, as well as retrofit options for higher thresholds.

CEC Question 4: What air quality considerations or benefits using blends should we be aware of?

SocCalGas Response:

- Concern for increased NOx in combustion technologies.
- Unknown impacts on SCR's (See UCI project in list above).
- Fuel cell demonstrations will have an immediate reduction in NOx.

CEC Response:

Staff appreciate the detailed feedback from SoCalGas. The comments and recommendations are valuable and will be taken into consideration either in the solicitation from this proposed initiative or in future research initiative development. Blending thresholds, emissions reduction, and engine work with manufacturers are integral to the proposed initiative (e.g., low GHG and NOx emissions will be part of studies and will ensure that projects are demonstrating low emissions that exceeds existing standards). Regarding engines, the intent is to maintain or exceed some of the attributes of the current fleet of natural gas power generators that are valuable in complementing the anticipated increases in intermittent renewables (e.g. due to fast start and ability to ramp up and down). The initiative is not prescribing specific engine technology but rather attributes that should be attained.

Energy-Related Environmental Research Program

Research Initiative #6: Quantify Exposures to Indoor Pollutants in Multi-Family Homesthat Cook with Natural Gas or Alternatives

CEC should engage experts in toxicology, epidemiology, and environmental chemistry in developing the scope for this initiative to ensure testing procedures provide meaningful information towards an understanding of potential residential exposures. The recently published(2020) UCLA Report by Zhu, et al[7] modeled peak concentrations from gas appliances and improperly compared these transient concentrations to 1-hour Ambient Air Quality Standards. Unfortunately, many people have drawn inaccurate conclusions from the UCLA Report based on these findings. CEC should ensure meaningful concentration data, for evaluation against established thresholds based on specific exposure durations, are collected aspart of this initiative. The study should also look at emissions from electric stoves for similar populations to reduce potential bias in the study results.

SoCalGas responses to CEC questions for the stakeholders:

CEC Question 1: How should the study population be defined? (e.g., multi-family households that include residents vulnerable to air pollution exposures, low-income single-family homes, etc.)

SocCalGas Response: A study of exposures in communities vulnerable to air pollution must look beyond indoor sources of particulate matter (PM) and oxides of nitrogen (NOx) when establishing the studypopulation. Unless confounding factors, such as proximity to busy roads, smoking, mold, and others are accounted for, the study could have an unintended bias.

CEC Question 2: How to foster cost-effective recruitment of the study population to ensure the research benefits the intended stakeholders?

[7] Zhu, et al, Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California. 2020.

SocCalGas Response: Without knowing the study population and objectives, it is difficult to identify recruitment possibilities.

CEC Question 3: Are there ongoing efforts that could be leveraged or otherwise provide fruitful partnerships?

SocCalGas Response: CEC may want to consider outreach to the AB 617 communities through the community steering committees established by the local air districts.

CEC Response:

Staff appreciate these thoughtful comments regarding the importance of engaging a researcher from a variety of relevant subdisciplines and controlling for external sources that can contribute to indoor air pollution. These comments will be taken into consideration in solicitation development to ensure meaningful, rigorous results.

Research Initiative #7: Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

The CEC will need to consider a range of issues when looking at decommissioning portions of the natural gas system – service reliability and cost impacts to customers that remain on the system, as well as resiliency and reliability of the energy grid (electric and natural gas). The natural gas system plays an increasingly important role in the reliability of the electric grid as more intermittent resources are added to the grid. The natural gas system continues to be a critical resource for long-term energy storage and for the fast-ramping capability of generating resources to provide low cost reliability for the electric grid.

If the primary focus of this analysis is to look at electrification scenarios, it will be equally important to look at the impacts on the local electric grid for the increased electric load in that region. Further, the analysis should consider the cost to the homeowner for upgrades to their electric panel and replacement of appliances. During a January 2021 update on the pilot projects in the San Joaquin Valley OIR, RH&A noted a majority of homes in disadvantaged communities require evaluation of upgrades to the electric grid. Similarly, PG&E noted 60% of homes in the pilot need electric service upgrades (transformer, secondary wire, etc.).[8] CEC should include these factors in their electrification studies.

SoCalGas responses to CEC questions for the stakeholders:

CEC Question 1: How can California's natural gas IOUs be effectively engaged in this study? What synergies with IOU priorities and planning could be leveraged to enhance the study?

SocCalGas Response: This initiative may be informed by the current Gas Transmission OIR at the CPUC. The utilities have been looking at different planning criteria as part of the proceeding.

CEC Question 2: What other natural gas sector stakeholders (e.g., other state agencies, CCAs, community- based organizations, jurisdictions with electrification

[8] January 19, 2021 presentations to CPUC on the San Joaquin Valley Pilot programs.

ordinances) could serve important roles in ensuring the study delivers useful results?

SocCalGas Response: The participants of the Gas Transmission OIR may be able to provide input for scoping thisresearch initiative.

CEC Question 3: What collaboration opportunities with related efforts could be most fruitful?

SocCalGas Response: CEC will need to work with the electric and natural gas utilities to evaluate the impacts on bothsystems.

CEC Response:

Staff appreciate these comments, which underscore the interrelationships between natural gas system planning and the electricity system as well as the need to coordinate proposed work with developments under CPUC's Gas Transmission OIR. However, impacts of electrification to the electricity sector infrastructure may fall under and be addressed by other research programs (e.g., EPIC). Additional stakeholder guidance and coordination with CPUC will inform the development of the solicitation and refine the scope to focus on areas where natural gas R&D funds can have highest impact.

Transportation Research Program

Research Initiative #8: Advanced Hydrogen Refueling Infrastructure Solutions for HeavyTransport

Current SoCalGas RD&D Projects that could inform development of this initiative:

- NREL MC Formula Protocol for H35HF Fueling - This project will tailor the SAE J2601 standard MC Formula protocol structure to 35MPa on-board storage systems for board storage systems for heavy duty vehicles utilizing H35HF (high flow) receptacles.
- GTI H2@Scale Hydrogen Refueling Demonstration - The H2@Scale project will include the demonstration of co-located multiple hydrogen generation and multiple hydrogen useapplications. Hydrogen will be used to generate electricity for a data center and refuelinga hydrogen fuel cell vehicle fleet.
- GTI Hydrogen Fuel Cell Yard Truck Port of Los Angeles Demonstration - Developmentof two hydrogen fuel cell yard trucks at the Port of Los Angeles and hydrogen mobile refueler.

SoCalGas responses to CEC questions for the stakeholders:

CEC Question 1: Given the limited research funds, what specific barriers should be prioritized to reduce the cost of high-capacity hydrogen fueling infrastructure for heavy transport?

- Standardized fueling protocols for light, medium, and heavy-duty transportation.

CEC Question 2: What are some opportunities for this research to inform development of codes and standards to create replicable solutions?

SocCalGas Response:

- Standardization of 700 and 350 bar refueling protocols.
- DOT standards for hydrogen transport and mobile refueling.

CEC Question 3: How can this research supplement private sector and other public investments in hydrogen fueling infrastructure research, demonstration, and deployment?

SocCalGas Response:

- Wet-hosing and mobile refueling can reduce the initial cost of hydrogen infrastructure needed to demonstrate and advance hydrogen fuel cell vehicle technology.
- Mobile refueling and infrastructure plays an important role for off-road applications where project locations change

CEC Response:

The proposed initiative focuses on hydrogen fueling infrastructure technology advancements that promote compatibility and standardization across multiple heavy-duty fuel cell vehicle types. Development of a high capacity mobile hydrogen refueler to emulate diesel wet hosing is identified as a possible research topic under this proposed initiative. We agree that this technology can be critical for supporting early vehicle demonstrations and off-road vehicles that lack access to permanent on-site infrastructure.

Conclusion

SoCalGas looks forward to continuing our valuable partnership with the CEC, developing new technologies that can help California reach its climate goals. We look forward to additional opportunities to collaborate with CEC, the U.S. Department of Energy, local air districts and the national laboratories. As the CEC looks to further develop their research initiatives for FY 2021/22, we look forward to working with CEC staff to share our experience and research resultsfrom our own portfolio.

Sincerely,

/s/ Tim Carmichael

Tim Carmichael
Agency Relations Manager
Southern California Gas Company

CEC Response:

CEC staff appreciate the comments and answers to our stakeholder questions. We appreciate SoCalGas's interest in sharing its experience and research results.

CPUC Staff Comments

CPUC Staff and CEC Staff Coordination Meeting

In resolution G-3571, the California Public Utilities Commission requested that in developing its Fiscal Year 2021-22 Plan, the CEC would amend its submission process to:

> "At least three weeks in advance of CEC's public workshop on the proposed budget plan, coordinate with CPUC staff in Energy Division and Safety and Enforcement Division. The goal of this additional step is to ensure the best possible use of funds across multiple programs."

To address that request, staff from CEC's Energy Research and Development Division held a meeting on January 8th with staff from CPUC's Energy Division and Safety and Enforcement Division. At the meeting, CEC staff presented the following:

- an overview of the development process,
- results from a survey that was sent to the Disadvantaged Community Advisory Committee (DACAG) and other interested parties to solicit input on the needs of low-income and disadvantaged communities to help inform the R&D plan, and
- the eight proposed initiatives.

The California Energy Commission appreciates the questions and thoughtful and helpful comments from CPUC staff during the coordination meeting on proposed initiatives for the FY 2021-22 Natural Gas R&D Program. Below is a summary of CPUC staff comments, which CEC staff incorporated into the plan, organized by initiative.

1. **Hydrogen** and Natural Gas Blending for Industrial End-Use Applications

- Initiative #1 was not included in the final R&D plan due to funding limitations.

2. Industrial Carbon Capture and Utilization

- Highlighted specific industries that we plan to target such as glass, cement, mentals, and chemicals.
- Did not specifically include or preclude blue hydrogen in the initiative but will consider including blue hydrogen when developing a solicitation.
- Did not include biogas or biomethane in the solicitation due to funding limitations and to target the industrial sector for greater impact helping that sector to decarbonize.
- Clarified the equity considerations and environmental impact.

3. Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages

- No comments were given for this initiative.
- Clarified equity considerations based on feedback on other initiatives.

4. Technology Development and Demonstration for Plastic Pipeline Repair **and** Integrity Improvement

- Clarified equity considerations

5. Developing and Demonstrating Hydrogen-Based Power Generation Systems

- Clarified material integrity as a potential research topic as it relates to hydrogen-based power generation systems.
- Clarified equity considerations.

6. Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives

- Clarified how this initiative is responsive to CPUC Resolution G-3571.
- Clarified the research gaps this initiative addresses.

7. Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

- Clarified equity considerations.

8. Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

- Clarified equity considerations and environmental benefits.\

Additional Comments

Unrelated to the eight proposed solicitations, CPUC staff suggested three potential research areas for CEC staff to consider for initiatives. CEC staff followed-up directly with the CPUC staff on these topics via email.

Topics CPUC Staff suggested

1. Look at supplements to livestock feed to reduce impact on GHG emissions and improve biomethane. Look at opportunities to change manure and biomethane production.
2. Related to renewable natural gas, look at the left-over material to see about market development to convert materials to biochar or fertilizers (to replace chemical fertilizers) and reduce GHG emissions.
3. Explore landfill methane and get to zero GHG. Significant methane from landfills are not being captured—should focus to bring to zero.

None of these topics were incorporated in the R&D plan. The first two are outside the scope of energy related research. The third has received research funding from the CEC in the past and CEC staff concluded that the topics included in the initiatives have more need for innovation.

DACAG Comments

Disadvantaged Communities Advisory Group Meeting

In resolution G-3571, the CPUC requested that in developing its Fiscal Year 2021-22 Plan, the CEC shall:

> "Coordinate more closely with the DACAG to solicit feedback, including earlier coordination to facilitate a presentation of the FY 2021- 22 Plan, if requested by the DACAG.
>
> "Increase efforts to identify and engage appropriate disadvantaged community stakeholders to provide feedback on the FY 2021-22 Plan and document those efforts in

the FY 2021-22 Plan. If feedback is not received by disadvantaged community groups on the draft plan, describe any barriers that must be overcome to receiving feedback on future plans."

To address that request, staff from CEC's Energy Research and Development Division attended and presented the draft R&D plan to the DACAG at their meeting on January 22nd. At the meeting, CEC staff presented the following:

- An overview of the Natural Gas R&D program and development process,
- Summary of results from a survey that was sent to the DACAG and other interested parties to solicit input on the needs of low-income and disadvantaged communities to help inform the R&D plan, and the eight proposed initiatives.

The California Energy Commission appreciates the questions and thoughtful and helpful comments from DACAG members on proposed initiatives for the FY 2021-22 Natural Gas R&D Program. A summary of the comments and CEC staff responses is provided below. The comments were not submitted in writing, nor are they word for word quotes, but do attempt to capture the intention of the verbally made comments during the meeting.

1. Hydrogen and Natural Gas Blending for Industrial End-Use Applications

Note: the comments and general responses on hydrogen / natural gas blending are applicable for both Initiatives 1 and 5.

Comment: Concerned about research around hydrogen blends and combustion. More research needed about NOx and other local criteria pollutants. Because the equity implication is so significant, research needs to address this before looking at potential end uses that requires combustion or blending. Transitioning away from natural gas is an incredibly important topic. Coal is in a decline and natural gas has a way to go. This research is required for a just transition. *Note: these comments were echoed by other members of the DACAG as well*.

CEC Response: During the meeting CEC staff responded by saying that we appreciate the comments and have the concern about NOX in our minds as a major part of the initiative and will investigate incorporating NOX further into the research initiative. Based on the feedback, CEC staff strengthened the importance of evaluating NOX emissions, investigation mitigation strategies to reduce NOX and other criteria emissions in any applications of hydrogen blends either decrease or not increase. However, due to funding limitations, initiative #1 was not included in the final R&D plan.

Comment: How does the idea of blending fuels change the perspective on gas itself and decommissioning plans of natural gas lines? Will this keep them longer?

CEC Response: CEC staff responded by saying that this is where there is an interaction of research and policy and that how the natural gas pipeline will transition is still evolving. This research effort isn't intended to determine the effect on decommissioning at this stage, rather it is intended to demonstrate the feasibility of blending hydrogen with natural gas for end-use industrial applications, determine the effect on criteria emissions from combustion, and generate data to characterize impacts that could inform state planning.

Initiative #1 was not included in the final R&D plan due to funding limitations.

2. Industrial Carbon Capture and Utilization

Comment: The presentation stated it very well that high temp industrial plants are frequently located in under-resourced communities. Hoping some of that research is in particulate matter emission, due to the emission burden DAC/LI communities face..

CEC Response: Based on CEC staff's research, it is anticipated that the nature of carbon capture processes will necessitate the removal of pollutants including particulates for the technology to work effectively. CEC staff updated the initiative for carbon capture processes to also address removal of impurities including criteria air pollutants and particulates.

3. Technologies for Monitoring Ground Movement Around Pipelines and Mitigating Natural Force Damages

No comments

4. Technology Development and Demonstration for Plastic Pipeline Repair and Integrity Improvement

No comments

5. Developing and Demonstrating Hydrogen-Based Power Generation Systems

The comments brought up for Initiative #1 on hydrogen blending are applicable here as well.

CEC Response: The general responses provided in Initiative #1 are applicable here. Specific to the Hydrogen-Based Power Generation Systems, the initiative includes investigating technologies that reduce emissions.

6. Quantify Exposures to Indoor Pollutants in Multi-Family Homes that Cook with Natural Gas or Alternatives

Comment: On indoor air quality in single family homes there have been several reports done by UCLA and Harvard that have looked at NG vs electric cooktops. Believe we have the answers to some of this. Can we just build on top of that?

CEC Response: CEC staff responded that we agree that there is already information available, but that it is incomplete. Prior to releasing a solicitation, we would hold a public workshop to help identify available research and research gaps.

7. Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning

Comment: PG&E Gas transmission pipeline is vast. Suggestion that the North Coast would be a good area for a pilot due to its single pipeline and powerplant that serve it. Invest in a social science component where decarbonization and pruning takes place for DAC & LI and engage with the communities to identify where pruning projects make sense. Social science of people attitudes with regards to electrification. Electric stove top used as an example.

Note: CEC staff thanked that DACAG member at the meeting and followed-up via email after the meeting to arrange a follow-on discussion.

Notes from a follow-on discussion: During the follow-on discussion the DACAG member described an area in more detail as a prime example of an example where location-specific analysis is needed due to the infrastructure and being in a seismically active area. The DACAG member supported looking into the transition to electric for LI communities that can't afford that best electrical appliances and how to encourage acceptance and adoption in those areas.

Expanding on the social science aspect, the DACAG member stressed the need to address the knowledge gas for electrical installation, service, and maintenance on the contractor side for those more familiar with natural gas. To build an adoption base for electrification, understanding and sharing the health impacts with supportive data would help.

CEC Response: CEC staff are in agreement with the need to ensure a just transition away from natural gas and the importance of the social science related research described, however that research not the focus of this initiative but may be considered for future initiatives. CEC staff agree with the importance of acquiring and sharing data on the health impacts of natural gas and a transition to electrification, which is addressed in initiative 6. CEC staff updated the initiative to address seismic activity.

8. Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Comment: Hydrogen fueling with heavy transport, how is this being coordinated with CEC's Fuels and Transportation Division (FTD) and the Clean Transportation Program (CTP)? Hydrogen has a carve out in that program.

CEC Response: CEC staff responded by saying that FTD primarily deploys commercially available infrastructure. This initiative focuses on advancing pre-commercial technology for hydrogen refueling stations for heavy duty vehicles. Hopefully, these technologies be incorporated in future CTP-funded infrastructure deployments.

APPENDIX C:
Funding Encumbrance Tables

Natural Gas Research Funds Encumbered Within Two Years of Budget Approval

Research Area	CPUC FY 2014-15 Approved Budget Plan	Total FY 2014-15 Funds Encumbered	Total FY 2014-15 Funds Disen-cumbered	CPUC FY 2015-16 Approved Budget Plan	Total FY 2015-16 Funds Encum-bered	Total FY 2015-16 Funds Disen-cumbered
Energy Efficiency	$8.60	$7.48	$0	$7.10	$7.10	$0
Renewable Energy and Advanced Generation	$3.50	$2.48	$0	$5.80	$5.80	-$1.18
NG Infra-structure Safety, Integrity*	$2.50	$4.68	$0	$1.00	$1.00	$0
Energy-Related Environmental Research*	$3.00	$3.62	$0	$3.30	$3.30	$0
Transportation	$4.00	$3.34	$0	$4.40	$4.40	-$1.50
TOTAL	$21.60	$21.60	$0	$21.60	$21.60	-$2.68

Amounts shown in table are in millions and rounded to the nearest $10,000.

Source: California Energy Commission

Natural Gas Research Funds Encumbered Within Two Years of Budget Approval

Research Area	CPUC FY 2016-17 Approved Budget Plan	Total FY 2016-17 Funds Encum-bered	Total FY 2016-17 Funds Disen-cumbered	CPUC FY 2017-18 Approved Budget Plan	Total FY 2017-18 Funds Encumbered	Total FY 2017-18 Funds Disen-cumbered
Energy Efficiency	$7.10	$5.20	$0	$6.60	$4.57	$0
Renewable Energy and Advanced Generation	$4.40	$5.02	$0	$4.00	$4.00	$0
Natural Gas Infrastructure Safety, Integrity*	$4.00	$3.87	$0	$5.00	$5.82	$0
Energy-Related Environmental Research*	$2.60	$2.69	$0	$3.00	$3.46	$0
Transportation	$3.50	$4.81	-$1.99	$3.00	$3.75	$0
TOTAL	$21.60	$21.59	-$1.99	$21.60	$21.60	$0

Amounts shown in table are in millions and rounded to the nearest $10,000.

Source: California Energy Commission

Natural Gas Research Funds Encumbered Within Two Years of Budget Approval

Research Area	CPUC FY 2018-19 Approved Budget Plan	Total FY 2018-19 Funds Encum-bered	Total FY 2018-19 Funds Disencum-bered	CPUC FY 2019-20 Approved Budget Plan	Total FY 2019-20 Funds Encumbered	Total FY 2019-20 Funds Disencumbered
Energy Efficiency	$6.00	$9.32	$0	$9.00	$.418	$0
Renewable Energy and Advanced Generation	$3.00	$0	$0	$3.00	$0	$0
Natural Gas Infrastructure Safety, Integrity*	$5.60	$5.60	$0	$2.00	$1.57	$0
Energy-Related Environ-mental Research*	$3.00	$4.36	$0	$0	$0	$0
Transportation	$4.00	$2.31	$0	$6.60	$0	$0
Natural Gas Strategic Plan (Cross-Cutting)	$0	$0	$0	$1.00	$0	$0
Natural Gas Small Grant Program	$0	$0	$0	$0	$0	$0
TOTAL	$21.60	$21.60	$0	$21.60	$1.99	$0

Amounts shown in table are in millions and rounded to the nearest $10,000.

Source: California Energy Commission

Natural Gas Research Funds Encumbered Within Two Years of Budget Approval

Research Area	CPUC FY 2019-20 Supplemental Budget Plan	CPUC FY 2019-20 Supplemental Funds Encumbered	CPUC FY 2019-20 Supplemental Funds Disencumbered
Energy Efficiency	$1.00	$0	$0
Renewable Energy and Advanced Generation	$0	$0	$0
Natural Gas Infrastructure Safety, Integrity*	$2.00	$2.00	$0
Energy-Related Environ-mental Research*	$2.00	$0	$0
Transportation	$0	$0	$0
Natural Gas Strategic Plan (Cross-Cutting)	$0	$0	$0
Natural Gas Small Grant Program	$2.29	$0	$0
TOTAL	$7.29	$2.00	$0

Amounts shown in table are in millions and rounded to the nearest $10,000.

* In Resolution G-3507 (June 25, 2015), the CPUC directed the CEC to prioritize natural gas research and development projects on climate change, drought, and natural gas safety. The CEC shifted funding to these high-priority research areas when strong research proposals were received.

** For the FY 2019-20 budget plan, approved on January 31, 2019, the CEC has committed the budget plan balance from FY 2019-20 and is executing agreements and encumbering funds.

Source: California Energy Commission