APPENDIX A:
Policies Supported by FY 2022-23 Gas R&D Program Initiative Themes

Policies Supported by Targeted Gas System Decommissioning Theme

- CPUC Rulemaking 20-01-007[1] establishes policies, processes, and rules to ensure safe and reliable gas systems in California and perform long-term gas system planning.
- Senate Bill 887 (Pavley, Chapter 673, Statutes of 2016) issued requirements to ensure the safety and integrity of gas storage facilities.
- Senate Bill 1371 (Leno, Chapter 525, Statutes of 2014) requires the CPUC to determine whether existing practices are effective at reducing methane leaks and promoting public safety, and whether alternative practices may be more effective.
- CPUC Order Instituting Investigation I1702002 under Senate Bill 380 (Pavley, Chapter 14, Statutes of 2016) determines the feasibility of minimizing or eliminating the use of the Aliso Canyon gas storage facility in Los Angeles County while maintaining energy and electric reliability for the region.
- CPUC Decision 19-10-054, Rulemaking 18-04-019, outlines strategies and guidance for climate change adaptation.
- Assembly Bill 1496 (Thurmond, Chapter 604, Statutes of 2015) requires the state to monitor methane hotspots.
- CARB's Short-Lived Climate Pollutant Reduction Strategy recommends actions to reduce emissions of short-lived climate pollutants, including from dairies, organics disposal, and wastewater.

Policies Supported by Decarbonization of End-Uses Theme

- Executive Order B-32-15 directed the development of the Sustainable Freight Action Plan, which establishes targets to improve freight system efficiency by 25 percent by 2030, deploy more than 100,000 freight vehicles and equipment capable of zero-emission operation, and maximize near-zero freight vehicles and equipment powered by renewables by 2030.

[1] https://www.buildingdecarb.org/cpuc-long-term-gas-planning-proceeding-updates.html, https://www.cpuc.ca.gov/proceedings-and-rulemaking

- Executive Order N-79-20 established statewide targets for 100 percent of passenger vehicle sales to be zero emission by 2035, for all off-road and drayage operations to be zero emission by 2035, and for all medium- and heavy-duty vehicle fleets to consist of zero-emission vehicles by 2045, where feasible.
- 2020 Mobile Source Strategy determines the pathways forward for various mobile source sectors that are necessary to achieve California's criteria pollutant, toxic air contaminant, and GHG reduction goals.
- Low Carbon Fuel Standard [2]reduces the full fuel-cycle carbon intensity of the transportation fuels used in California by encouraging the transition to fuels that have a lower carbon footprint.
- Final *2020 Integrated Energy Policy Report Update*, Volume I: Blue Skies, Clean Transportation,[3] focuses on California's transportation future and transition to zero-emission vehicles. The report evaluates current transportation trends, challenges, and opportunities for dramatically cutting emissions, achieving state goals for zero-emission vehicles.
- Senate Bill 1369 (Skinner, Chapter 567, Statues of 2018) requires the consideration of green electrolytic hydrogen as a form of energy storage, and other potential uses of green electrolytic hydrogen.

Policies Supported by Energy Efficiency Theme

- Assembly Bill 3232[4] (Friedman, Chapter 373, Statutes of 2018) required the CEC to study opportunities for 40 percent reduction in GHG emissions from buildings by 2030. The California Building Decarbonization Assessment[5] addresses the AB 3232 requirements by analyzing scenarios to reduce GHG emissions by at least 40 percent by 2030 and identifies several strategies that will lead to significant emission reductions.
- Energy Code (Title 24, Part 6) applies to newly constructed buildings and retrofits to reduce wasteful and unnecessary energy consumption and save consumers money. The CEC updates the Energy Code triennially. The most

[2] https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard/about

[3] Gee, Quentin, Stephanie Bailey, Jane Berner, Michael Comiter, Jim McKinney, and Tim Olson. 2021. *Final 2020 Integrated Energy Policy Report Update*. California Energy Commission Publication Number: CEC-100-2020-001-V1-CMF.

[4] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB3232

[5] Kenney, Michael, Nicholas Janusch, Ingrid Neumann, and Mike Jaske. 2021. California Building Decarbonization Assessment. California Energy Commission. Publication Number: CEC-400-2021-006-CMF. Available at: https://www.energy.ca.gov/publications/2021/california-building-decarbonization-assessment

recent version is the 2022 update,[6] which becomes effective January 1, 2023. The updates related to the state's building decarbonization strategy include heat pump technology, solar PV, battery storage, mandatory "electric ready" and" energy-storage ready" requirements, lighting, building envelope, mechanical systems, and mechanical ventilation.

- Appliance Energy Efficiency Standards (Title 20, Division 2, Chapter 4, Article 4, Sections 1601–1608: Appliance Efficiency Regulations)[7] address water and energy efficiency standards for non-federally regulated appliances. These regulations include most major residential and commercial appliances sold or offered for sale in California.
- Final *2021 Integrated Energy Policy Report*, Volume 1, Building Decarbonization[8] covers a broad range of topics, including building decarbonization, energy efficiency, challenges with decarbonizing California's gas system, quantifying the benefits of the Clean Transportation Program, and the California Energy Demand Forecast.
- 2019 California Energy Efficiency Action Plan[9] addresses issues, opportunities, and savings estimates pertaining to energy efficiency in California's buildings, industrial, and agricultural sectors and focuses on doubling energy efficiency savings by 2030, removing and reducing barriers to energy efficiency in low-income and disadvantaged communities, and reducing GHG emissions from buildings.
- Local ordinances: Local jurisdictions are increasingly adopting electric-preferred, all-electric, and gas infrastructure-limiting local ordinances.[10] For example, 42 local jurisdictions in California have adopted energy ordinances more stringent than state standards, with 26 requiring all-electric construction and an additional 10 banning or limiting the installation of new gas lines as of October 2021.[11]

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[6] California Energy Commission. July 14, 2021. 2022 California Energy Code, Title 24 Parts 1 and 6. https://efiling.energy.ca.gov/GetDocument.aspx?tn=238848.

[7] Appliance Efficiency Regulations - Title 20 (ca.gov)

[8] Kenney, Michael, Jacob Wahlgren, Kristina Duloglo, Tiffany Mateo, Danuta Drozdowicz, and Stephanie Bailey. 2022. Final 2021 Integrated Energy Policy Report, Volume I: Building Decarbonization. California Energy Commission. Publication Number: CEC-100-2021-001- V1. 2021 Integrated Energy Policy Report (ca.gov). Available at: https://www.energy.ca.gov/publications/2021/2021-integrated-energy-policy-report

[9] Kenney, Michael, Heather Bird, and Heriberto Rosales. 2019. 2019 California Energy Efficiency Action Plan. California Energy Commission. Publication Number: CEC-400-2019-010-SF.

[10] Kenney, Michael, Jacob Wahlgren, Kristina Duloglo, Tiffany Mateo, Danuta Drozdowicz, and Stephanie Bailey. 2021. Draft 2021 Integrated Energy Policy Report, Volume I: Energy Efficiency and Building, Industrial, and Agricultural Decarbonization. California Energy Commission. Publication Number: CEC-100-2021-001-V1.

[11] Ibid.

APPENDIX B:
CPUC Resolution G-3584 Funding Encumbrance — Unspent Funds

Per the CPUC's request in Resolution G-3584, Appendix C shows the research funds from FY 2014–15 to FY 2021–22 Gas R&D Program budget plans encumbered within two years of budget approval. Per CPUC's request in Resolution G-3555, the CEC will ensure that for any use of encumbered and unspent funds that the CEC requests for new projects, the request will identify the respective research areas for which the CPUC originally authorized the funding.

Gas R&D Funds Encumbered

Research Area	CPUC FY 2014-15 Approved Budget Plan	Total FY 2014-15 Funds Encumb-ered	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 Infrastructure 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

Gas R&D Funds Encumbered

Research Area	CPUC FY 2015-16 Supplemental Approved Budget Plan	Total FY 2015-16 Supplemental Funds Encumbered	Total FY 2015-16 Supplemental Funds Disencumbered	CPUC FY 2016-17 Supplemental Approved Budget Plan	Total FY 2016-17 Supplemental Funds Encumbered	Total FY 2016-17 Supplemental Funds Disencumbered
Energy Efficiency	$0	$0	$0	$.91	$0	$0
Renewable Energy andAdvanced Generation	$0	$0	$0	$0	$0	$0
Gas Infrastructure Safety,Integrity*	$1.50	$1.50	$0	$1.70	$2.61	$0
Energy-Related Environmental Research*	$2.10	$2.10	$0	$2.70	$2.70	$0
Transportation	$0	$0	$0	$0	$0	$0
TOTAL	**$3.60**	**$3.60**	**$0**	**$5.31**	**$5.31**	**$0**

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

Source: California Energy Commission

Gas R&D Funds Encumbered

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 Energyand Advanced Generation	$4.40	$5.02	$0	$4.00	$4.00	$0
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

Gas R&D Research Funds Encumbered

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	$7.99	$0
Renewable Energyand Advanced Generation	$3.00	$0	$0	$3.00	$2.89	$0
Gas Infrastructure Safety,Integrity*	$5.60	$5.60	$0	$2.00	$1.58	$0
Energy-Related Environ-mental Research*	$3.00	$4.36	$0	$0	$0	$0
Transportation	$4.00	$2.31	$0	$6.60	$6.50	$0
Gas StrategicPlan (Cross-Cutting)	$0	$0	$0	$1.00	$1.00	$0
Gas Small Grant Program	$0	$0	$0	$0	$0	$0
TOTAL	**$21.60**	**$21.60**	**$0**	**$21.60**	**$19.96**	**$0**

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

Source: California Energy Commission

Gas R&D Funds Encumbered

Research Area	CPUC FY 2019-20 Approved Supplemental Budget Plan**	CPUC FY 2019-20 Supplemental Funds Encumbered	CPUC FY 2019-20 Supplemental Funds Disencumbered	CPUC FY 2020-21 Approved Budget Plan**	Total FY 2020-21 Funds Encumbered	Total FY 2020-21 Funds Disencumbered
Energy Efficiency	$1.00	$0	$0	$3.00	$0	$0
Renewable Energy and Advanced Generation	$0	$0	$0	$4.00	$0	$0
Gas Infrastructure Safety, Integrity*	$2.00	$2.00	$0	$9.10	$1.44	$0
Energy-Related Environ-mental Research*	$2.00	$0	$0	$1.50	$0	$0
Transportation	$0	$0	$0	$4.00	$0	$0
Gas Strategic Plan (Cross-Cutting)	$0	$0	$0	$0	$0	$0
Gas Small Grant Program	$2.29	$2.29	$0	$0	$0	$0
TOTAL	**$7.29**	**$4.29**	**$0**	**$21.60**	**$1.44**	**$0**

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

Source: California Energy Commission

Gas R&D Funds Encumbered

Research Area	CPUC FY 2021-22 Approved Budget Plan**	Total FY 2021-22 Funds Encumbered	Total FY 2021-22 Funds Disencumbered
Energy Efficiency	$6.10	$0	$0
Renewable Energy and AdvancedGeneration	$4.00	$0	$0
Gas Infrastructure Safety,Integrity*	$4.00	$0	$0
Energy-Related Environ-mentalResearch*	$3.50	$0	$0
Transportation	$4.00	$0	$0
Gas Strategic Plan (Cross-Cutting)	$0	$0	$0
Gas Small Grant Program	$0	$0	$0
TOTAL	**$21.60**	**$0**	**$0**

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

Source: California Energy Commission

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

**The CEC has committed the budget plan balance from the following budget plans and will be executing agreements and encumbering funds.

FY 2019-20 Baseline Budget Plan, approved August 1, 2019 by CPUC Resolution G-3555

FY 2019-20 Supplemental Budget Plan, approved August 1, 2019 by CPUC Resolution G-3555

FY 2020-21 Baseline Budget Plan, approved November 5, 2020 by CPUC Resolution G-3571

FY 2021-22 Baseline Budget Plan, approved September 23, 2021 by CPUC Resolution G-3584

*** Funds Disencumbered:

For the FY 2015-16 Budget Plan Disencumbered Funds, $2.68 million was from canceled agreements.

For the FY 2016-17 Budget Plan Disencumbered Funds, $1.99 million was from canceled agreements.

APPENDIX C:
Public Comment and CEC Responses

The California Energy Commission (CEC) appreciates the comments and questions received during and in response to a public workshop and two coordination meetings with California Public Utilities Commission (CPUC) staff and representatives of the Disadvantaged Communities Advisory Group (DACAG) on proposed initiatives for the FY 2022-23 Gas Research and Development (Gas R&D) Program Budget Plan. The workshop and meetings are summarized below. The comments and CEC staff responses for each are provided in the following sections:

- On January 12, 2022, CEC staff held a coordination meeting with 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 19, 2022, 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 21, 2022, CEC staff met with representatives of the DACAG 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.

CPUC Staff Coordination Meeting Comments and CEC Responses

Staff from CEC's Energy Research and Development Division held a meeting on January 12, 2022 with staff from CPUC's Energy Division and Safety and Enforcement Division. At the meeting, CEC staff presented the seven proposed initiatives for the FY 2022-23 Gas R&D Program Budget Plan. The CEC appreciates the helpful questions and comments from CPUC staff during the coordination meeting. Below is a summary of CPUC staff comments and CEC staff responses organized by initiative.

1. **Scaled-up Gas Decommissioning Pilots and Integrated Planning Tools**
    - Highlighted importance of local considerations and appropriate timing to engage disadvantaged communities in gas decommissioning efforts.
    - Suggested prioritizing more investment in this initiative to support additional or larger decommissioning pilots. Investment in gas decommissioning research is limited beyond the Gas R&D Program despite its importance for informing key policy decisions.
    - Provided information on the Equitable Building Decarbonization Program included in the Budget Act of 2021, which focuses primarily on direct installations.
2. **Large-volume Hydrogen Storage for Targeted Use Cases**

- Suggested incorporating a contingency strategy to redirect funding from hydrogen storage to gas decommissioning in the case of hydrogen storage funding in the FY22-23 state budget.
- Suggested refining initiative or future solicitation to focus on safety and existing gas fields because other investors would need to conduct their own studies to characterize geological storage.
- Discussed potential to leverage research proposals for pipeline components as discussed at the Pipeline and Hazardous Materials Safety Administration (PHMSA)'s Pipeline Transportation and Emerging Fuels R&D Public Meeting and Forum to identify gaps and prevent duplication of efforts.
- CEC staff addressed questions relating to a research topic under the EPIC Program (chemical storage of hydrogen, such as through metal hydrides).

3. Industrial Clusters for Clean Hydrogen Utilization

- CEC staff addressed questions relating to safety considerations for industrial hydrogen clusters, especially for communities located near existing industrial locations that are already bearing the burden of existing fossil fuel infrastructure.
- CEC staff addressed questions relating to related hydrogen projects and funding, including HyDeal LA and federal funding opportunities, and clarified that these efforts will be considered during the solicitation development phase.

4. Mitigating Criteria Air Pollutants in Hydrogen-Based Power Generation

- CPUC staff inquired about differences between investments in hydrogen-based power generation research under the Gas R&D and EPIC Programs. CEC staff clarified that Gas R&D Program is focused on smaller systems and reducing reliance on fossil gas. The EPIC Program is focused on potentially larger systems and advancing clean dispatchable generation to improve grid reliability.

5. Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

- CEC staff clarified the CEC's active coordination with SoCalGas, who are interested in similar transportation research and often participate in Gas R&D Program-funded projects as match partners.
- CEC staff clarified the CEC's active coordination with the Port of Los Angeles and Port of Long Beach through the CEC's Ports Collaborative to identify technology gaps and barriers related to hydrogen, such as the need for mobile refuelers to support cargo handling equipment.
- CEC staff clarified the costs of hydrogen as transportation fuel today and the initiative's role in reducing these costs for future heavy-duty stations.
- CEC staff clarified that the initiative does not target airports due to uncertainty about demand for hydrogen. CEC staff is participating on the Technical Advisory Committee for the H2 Airports Ecosystem Study funded by SoCalGas to track potential research needs.

6. Analysis of Residential Hot Water Distribution Designs

- Commented on the potential for this initiative to inform development of an energy efficiency measure or incentive for certain residential hot water recirculation systems.

- CEC staff clarified that the initiative intends to analyze and compare the energy use of various residential hot water recirculation systems.

7. CalSEED – Low-Carbon Gas

- Commented on need to consult the DACAG for perspective on this initiative, particularly for ensuring diversity in applicants for the small grants program.

Additional Comments:

- Suggested consideration of adjusting initiative investments pending the status of new state and federal funding, especially for the hydrogen-related initiatives.
- Sought clarity on how the CEC chose these specific hydrogen-related initiatives to study by targeting sectors that are difficult to decarbonize such as industrial, power generation, and heavy transport.
- Clarified the integration of pipeline safety-related research throughout the initiatives including those related to gas decommissioning and large-volume hydrogen storage.
- Suggested including a research initiative with biogas due to increased organics diversion required by SB 1383. CEC staff clarified that this suggestion would not be incorporated into the FY 2022-23 Gas R&D budget plan because the topic has received research funding in recent plans and there may be overlap with the California Department of Food and Agriculture (CDFA) investments in biogas projects.

Public Workshop Comments and CEC Staff Responses

The CEC appreciates the thoughtful and helpful comments from stakeholders received in response to CEC's January 19, 2022 Gas R&D Workshop, where staff presented proposed initiatives for the FY 2022-23 Gas R&D Program Budget Plan. The workshop was attended by 183 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 19, 2022 workshop and via notifications on the CEC website, listservs, and docket. A summary of the written comments and CEC's responses is provided below. Please note that for brevity, footnotes included in public comments are not included in this summary.

Initiative Theme: Targeted Gas System Decommissioning

Initiative Title: Scaled-up Gas Decommissioning Pilots & Integrated Planning Tools

Comment Received from: SoCalGas

CEC Question: What are potential challenges to large-scale pilots?

SoCalGas is fully committed to advancing California's decarbonization goals and finding the feasible levers for achieving net-zero carbon emissions. Some of the key challenges to large-scale pilots include:

1. Electrification/decommissioning pilots have not been tested or validated at any scale,
2. Emissions reductions are projected to result from *electrification,* not decommissioning; and
3. Going from concept to practice could result in significant costs to ratepayers with little to no commensurate benefits.

Because the concept of targeted electrification coupled with decommissioning has been advanced as a prospective building decarbonization lever, we are participating in a feasibility investigation, including implementing the project's zonal electrification/decommissioning pilot project within our distribution system. However, one takeaway from the workshop is that future policymaking will benefit from taking a clear objective approach to these early-stage efforts, which can inform, for the first time, the practical feasibility and cost-effectiveness of a prospective zonal electrification/decommissioning strategy. Workshop participants pointed out that certain early- stage data points for getting to scale are informative. Specifically, workshop presenter Amber Mahone of E3 stated that to date, such an approach is hypothetical as it has not been demonstrated in practice at any scale. She articulated that,

> "[…] out of our prior work, as well as the work of others, has emerged a hypothesis, which is the idea that targeted electrification in geographically specific regions could be combined with strategic decommissioning of gas infrastructure in order to reduce total gas system costs and thereby help to mitigate future rate impacts for remaining customers. Now that hypothesis hasn't been tested or validated at any scale, and so this research is sort of a first step towards further investigation of that (emphasis added)."

It appears prudent and in the public interest for the State to assess the results of this pilot study and the most recent grant funding opportunity before dedicating additional funds from the 2022-23 fiscal year budget. This approach allows for the CEC to focus its budget informed by fact-based outcomes of its pilot programs to address those opportunities that have exhibited appropriate levels of benefits and cost-effectiveness.

Additionally, we would emphasize that *emissions reductions are projected to result from electrification, not from decommissioning.* During the workshop Q&A, a workshop presenter revealed that decommissioning does not necessarily bear a causal relationship to reducing emissions. Ari Gold of E3 stated that "emissions are not likely to be a driving factor for [decommissioning pilot] site selection" and that "the carbon avoided might be very similar in untargeted electrification versus targeted electrification." He went on to explain that "[b]ut only in that latter case, would you have the opportunity to start exploring some of these options for strategic decommissioning of gas system infrastructure." Put another way, the zonal electrification/decommissioning hypothesis is premised on electrification as the implement for reducing emissions. On the other hand, decommissioning arises only as a prospective mitigant for the rate impacts resulting from electrification rather a direct driver for underlying emissions reductions themselves. It is thus important to recognize as part of these considerations that decommissioning does not necessarily equate to emission reduction.

Moving forward with the CEC-sponsored pilot project is also critical to investigating the costs of a prospective zonal electrification/decommissioning strategy. The limited experience and

initial data to date suggest that going from concept to practice will be costly for the State and ratepayers. A recent analysis by the City of San Francisco estimates the costs of electric appliance retrofitting for San Francisco residences to range from $14,363 per housing unit at the low end, up to $19,574 for multi-family units and $34,790 for single-family homes. It estimates the citywide cost to retrofit all residential units using natural gas-fueled appliances with electric ones from $3.5 to $5.9 billion. Workshop presenter David Sawaya confirmed the high costs of electrification when discussing Pacific Gas and Energy Company's (PG&E) experiences. He stated,

> "[W]e cannot fund electrification projects at scale using gas rates and expect to have a benefit in terms of reduction of rates on the gas side on the gas bill, because the electrification of the individual premises is very expensive in our experience. Generally speaking, we're talking about anywhere from $25[,000] to $50,000 per resident if we're talking about residential in order to electrify them. So, when you start talking about projects at the scale of 50 or 100 homes those numbers start getting very big very quickly and quickly outstrips the potential savings that you would have."

PG&E's experience, while limited, reinforces the need to thoroughly assess the feasibility and financial challenges to homeowners and building owners. A 2021 research paper by the Energy Institute at Haas proposes to address potential inequitable customer cost impacts resulting from electrification "through the general tax base rather than from utility customers." This approach, coupled with the high homeowner cost of building electrification, raises the possibility of subsidies being required in order to offset costs to households and building owners to electrify, and then adding on additional tax revenue-funding in order to address the fixed cost impacts of electrification on remaining gas customers. However, additional data is needed on the cost implications resulting from electrification, particularly insofar as they may impose disproportionate community and household impacts particularly in light of more vulnerable customer groups.

It is imperative that the necessary decarbonization policies, especially those adopted for widespread implementation and with equally widespread effect, such as the zonal electrification/decommissioning hypothesis, are also developed with a thorough and fact-based understanding of prospective consequences and results. SoCalGas remains fully engaged in this investigation and all such relevant efforts to explore implementation of decarbonization levers in the future.

CEC Staff Response:

In the context of California's gas system, CEC staff understand emission reductions to be achieved from reduction of fossil fuel combustion — whether through substitution of fossil gas with lower carbon electricity, decarbonization of the fossil gas system through introduction of low-carbon pipeline fuels, or other strategies that reduce fossil fuel consumption. CEC staff are aware of the challenges articulated by SoCalGas, including the lack of precedent for large-scale piloting of decommissioning or electrification as well as the substantial investment required for decommissioning and electrification. This research initiative aims to build on previous and ongoing research regarding decommissioning pilots, focusing on decommissioning opportunities that are replicable and scalable to meet California's decarbonization goals. The learning from existing research indicates that small-scale pilot projects (a long gas pipeline with a few customers) can be cost-effective and less risky, but large-scale deployment is required to achieve the state's goals for decarbonization. Results from this research initiative

will help inform stakeholders on financial, programmatic, legal and regulatory actions for the challenges listed above.

Further, staff agree that findings from the SoCalGas feasibility investigation and zonal electrification and decommissioning pilot can provide valuable information to inform research resulting from this initiative. We welcome opportunities to learn from the SoCalGas pilot and plan to build on existing research and insights throughout implementation of this research initiative. A key motivation for the initiative is to improve understanding of the experiences of gas users during the entire process of customer-side electrification, so that this understanding can be better incorporated into electrification and decommissioning planning. This customer-side research is expected to include an investigation of the costs of electrifying premises, as covered in the San Francisco study and PG&E estimates mentioned, as well as identifying and examining other important community and gas customer elements that must be considered in moving from concept to practice in larger-scale electrification or decommissioning.

Comment Received from: National Fuel Cell Research Center (NFCRC)

CEC Question: What emerging zero-carbon fuels should be considered by the planning tool?

The NFCRC recommends that the planning process for gas decommissioning should be more optimally construed. Conversion, suspending operations and complete decommissioning should only happen after the CEC determines that the system or certain parts of the system will be neither used nor useful in the future. CEC decisions and premature presentation of gas decommissioning can have the unintended consequence of stifling the investment and necessary research and demonstration for zero carbon solutions using the gas grid.

The overall study for the optimal decarbonization of all sectors of the economy should be accomplished before gas system decommissioning should commence. This is particularly important given the very recent policy decisions all around the world (e.g., China, Japan, Australia, all of Europe, and most recently in the U.S.) to focus investment and support of hydrogen production, storage, distribution and conversion to support zero emissions policy goals. If announced targets, such as the $1 for 1 kilogram within 1 decade of the U.S. Department of Energy are achieved, the cost-optimal decarbonization of all sectors of the economy are likely to significantly include gas system transformation to use renewable hydrogen (rather than decommissioning).

The NFCRC recommends that the CEC analyze scenarios to identify the optimal means to reliably transform the entire energy system to one that is zero carbon. The economics of alternatives for 100 percent decarbonized gas system should consider:

- Magnitude and dynamics of all stationery and transportation gas demand,
- Magnitude of storage resources required to reliably meet such demand throughout the year with very high use (near 100%) of renewable power,
- Cost and resiliency of transforming all demand to electricity and using only electric infrastructure and electricity storage technologies to achieve near 100% renewable energy in the state,

- Cost and resiliency of transforming many loads to electricity and using both the gas and electric infrastructures for storing, transmitting and distributing near 100% renewable energy in the state, and
- Cost of engendering resiliency in the context of increased wildfires and public safety power shutoff (PSPS) events.

CEC Staff Response:

CEC staff concur that it is important to consider a variety of pathways for decarbonizing the fossil gas system, including regionally specific opportunities and constraints. The draft FY 2022-23 Gas R&D budget plan proposes to expand CEC's R&D in the decommissioning space to consider some of the issues articulated by NFCRC, including analysis of potential roles of emerging zero-carbon energy sources that could leverage gas infrastructure. Recognizing the imperative to accelerate emission reductions to meet California's climate goals, the FY 2022-23 Gas R&D budget plan proposes initiatives that consider a variety of proactive pathways toward decarbonization of California's gas system.

CEC Question: What are potential challenges to large-scale pilots?

NFCRC suggests that an alternative to decommissioning be considered in all of these pilots considering the potential for production and delivery of low-cost renewable hydrogen use for decarbonization.

CEC Staff Response:

The FY 2022-23 Gas R&D budget plan includes the analysis of the potential roles of renewable, low-carbon hydrogen for hard-to-electrify industry, heavy duty transport, and dispatchable generation, as well as hydrogen storage to support these potential end uses. Additionally, the FY 2020-21 Gas R&D budget plan included research initiatives on hydrogen production, pipeline blending, and end use applications. The projects from these research initiatives are expected to start in 2022, which will lay the groundwork for future pilots for the production and delivery of renewable, low-carbon hydrogen.

CEC Question: What are the best practices in customer engagement on gas-to - electricity transition?

CEC should consider the following impacts to customers when analyzing gas-to-electricity scenarios:

How does gas decommissioning affect reliability of the electric grid?

- What is the required increase in electricity to meet the new demand transferred from the gas system?
- How does California plan for such an increase in electric demand and what timeline is necessary for such a transition?
- What is the new infrastructure cost? System cost? Customer cost?

CEC Staff Response:

CEC staff acknowledge the importance of assessing a range of possible future impacts of electrification with the intent of assessing and shaping potential options (including timelines, system capacity and reliability, costs, technologies, and policies) for decarbonization pathways going forward. These results would inform dialogues on decarbonization strategies and decarbonization research needs. Comments and recommendations articulated by stakeholders will be taken into consideration during the development of solicitations for large-scale decommissioning pilots and planning tools.

CEC Question: What are the recommendations on minimizing cost impacts and supporting equity?

Disadvantaged communities will likely need significant investment in electrical infrastructure and significant financial support (e.g., incentives for electric appliances) for their purchase of electric alternatives to their current use of gas. Assessment of the magnitude of financial support needed throughout the state of California should be included as soon as possible. Assessment of the alternative decarbonization through the use of renewable hydrogen in these same disadvantaged communities is merited.

CEC Staff Response:

Staff appreciate the input provided on the multiple elements that need to be considered when analyzing transitioning from fossil gas. This research initiative will help address the potential barriers and considerations related to equitably transitioning disadvantaged and low-income customers off the gas system and supporting strategic investments in vulnerable communities. Further, the research resulting from the initiative is expected to include an assessment of the costs of electrifying household and business premises, and how these costs vary across different circumstances and communities, including disadvantaged communities. NFCRC's comments and recommendations, including the need to assess financial dimensions and alternative pathways to decarbonizing buildings in under-resourced communities, will be taken into consideration during the development of solicitations for large-scale decommissioning pilots and planning tools.

Comment Received from: California Hydrogen Business Council (CHBC)

CEC Question: What emerging zero-carbon fuels should be considered by the planning tool?

The CHBC appreciates the opportunity to submit comments on the CEC Proposed Natural Gas and Research and Development Workshop ("Gas R&D Workshop"), discussing the proposed energy-related gas research initiatives for fiscal year 2022-2023.

To summarize CHBC's responses to the questions for stakeholders is that the CEC should capitalize on existing resources like research previously done by other countries transitioning their gas grids to hydrogen, the CEC should plan an immediate response to the climate crisis by incorporating existing gas grid infrastructure into the decarbonization plan, and the CEC should offer more detailed questions to gather more informed responses on a topic as critical

as gas grid research and development. The CHBC respectfully submits the following responses to the Gas R&D Workshop request for feedback.

The gas decommissioning tool should not focus on the decommissioning of our existing gas infrastructure, but instead should focus on improving gas infrastructure to withstand zero-carbon fuels like hydrogen. Hydrogen has been successfully blended into the existing natural gas system at 20 percent which starts the transition to decarbonizing the gas grid. The second step, which has been successfully piloted, is to replace aging metal pipelines with polyethylene pipelines that can carry a 100 percent hydrogen blend and completely decarbonize the gas grid.

CEC Staff Response:

As presented at the Gas R&D workshop on January 19, 2022, analyzing the potential role of hydrogen and other zero-carbon sources, and the implications of this potential for electrification and decommissioning activity in the state, is anticipated to be an important element in this initiative.

CEC Question: What are potential challenges to large-scale pilots?

The potential challenge going forward with large-scale gas decommissioning pilots is that time is limited in our response to climate change and the technological solutions already exist. In 2020, natural gas alone accounted for 40 percent of California's power generation. Natural gas serves as the source for many sectors and functions that require too much power for the state's electric grid to support now or in the near future, including heavy industry, building heat, water heat, and chemical production. Additionally, the state's electrical grid was only 33 percent renewable in 2020, meaning fossil fuels were used for theremaining 67 percent of power on the electric grid. Therefore, the state must utilize the resources available today to begin decarbonization by researching and developing a transition to a zero-carbon gas grid using hydrogen.

CEC Staff Response:

CEC staff acknowledge the magnitude and urgency to achieve California's decarbonization goals. Potential gas system decarbonization R&D supported by the FY 2020-21 Gas R&D budget plan will focus on the decarbonization of the power and industrial sectors with hydrogen or blended hydrogen, assess the possibility of repurposing existing gas infrastructure available for various hydrogen blends up to 100 percent, and examine different upgrade options and associated costs. The FY 2022-23 Gas R&D budget plan will not dedicate additional funds to these topics due to other priorities and limited research funds.

What are the best practices in customer engagement on gas-to-electricity transition?

The CHBC has no comment to offer on this topic.

What are the recommendations on minimizing cost impacts and supporting equity?

To minimize cost impacts of transitioning the state's gas grid to hydrogen the CHBC

recommends the CEC save resources by researching the pilots that have already been deployed in the UK for its gas grid transition andreshape the research and development for deployment in California. As noted in the footnotes, HyDeploy in the UK has successfully distributed a 20 percent hydrogen blend through existing metal pipelines and several studies have been completed to show a full hydrogen transition is possible with polyethylene pipes.

CEC Staff Response:

CEC staff appreciate the additional references provided by CHBC and acknowledge the importance of leveraging resources and learnings from past research to inform the R&D for deployment in California. Pertaining to the hydrogen blending research, the CEC released a solicitation GFO-21-507 'Targeted Hydrogen Blending in Existing Gas Network for Decarbonization' funded through the FY 2020-21 Gas R&D budget plan. The CEC considered all publicly available research results during the development of that solicitation, including the research in the UK.

In addition, staff welcome more detailed comments on these topics. Comments related to the gas system can be submitted to the PIER docket (or other dockets) at any time; all comments will be carefully reviewed. Analyzing the potential role of hydrogen and other zero-carbon sources, and the implications of this potential for electrification and decommissioning activity in the state is anticipated to be an important element in this initiative. Fossil gas still plays an significant role in California's energy system. An integrated approach considering a variety of options will be required to decarbonize the energy system. Reviewing recent and ongoing gas system transition pilots elsewhere, including outside the United States, will be included in the anticipated research.

Initiative Theme: Decarbonization of Gas End-Uses

Initiative Title: Large-Volume Hydrogen Storage for Targeted Use Cases

Comment Received from: Rockpoint Gas Storage

CEC Question: What are the promising use cases and suitable geological storage opportunities in California?

Existing gas storage facilities in the state are excellent use cases for hydrogen storage – either through hydrogen blending with natural gas or through segregated hydrogen storage at such facilities. Natural gas storage facilities have existing infrastructure to accommodate hydrogen storage and wells can be readily injected with blended hydrogen. Additionally, existing wells can be segregated for pure hydrogen storage.

Rockpoint is currently exploring all potential uses of hydrogen in its gas storage facilities and intends on being a key part of the energy transition – particularly as it relates to hydrogen blending and hydrogen storage.

CEC Response:
CEC staff will further refine our research scope during the solicitation phase. The comments and recommendations will be taken into consideration in future solicitations for geological storage opportunities.

CEC Question: Recommendations on research approach(es)?
Rockpoint encourages the Commission to engage with the private sector which has the existing infrastructure and will to move forward with geologic hydrogen storage. To that end, Rockpoint would be open to conversations with the Commission regarding potential participation in research initiatives and leveraging any shared learning where it exists.

Rockpoint can be reached at the coordinates below.

James Bartlett
Senior Legal Counsel
James.bartlett@rockpointgs.com
403-471-4754
#400, 607 8th Ave, SW
Calgary, Alberta

CEC Response:
The CEC will consider all publicly available research results pertaining to geologic hydrogen storage in solicitation development. The CEC will collaborate with the private sector and others to leverage existing research results.

Comment Received from: CHBC

CEC Question: What are the promising use cases and suitable geological storage opportunities in California?

Hydrogen is a long-term energy storage solution that can capture the renewable power produced by the state's wind and solar resources to avoid curtailment. Once stored, hydrogen can be distributed through the gas pipelines or pumped through a fuel cell to support the electric grid, to power the state when renewable energy production is low or inoperable due to extreme weather events. Hydrogen has the potential to be stored geologically in salt caverns, which is being tested in Utah for the Advanced Clean Energy Storage project, and in depleted oil fields with the proper mineralogical composition. The CHBC recommends the CEC support research and development of long-term hydrogen storage in depleted oil fields to utilize existing resources.

CEC Response:
Dispatchable power generation using green hydrogen is considered as one of the targeted use cases. The recommendation of salt caverns and utilizing existing gas storage fields for hydrogen storage will be taken into consideration in future solicitations for geological storage opportunities.

CEC Question: What types of requirements should inform geological storage decision making?

The CHBC recommends the CEC implement safety requirements related to long-term hydrogen storage in depleted oil fields.

CEC Response:

Safety is considered as one of the research priorities. The research will help minimize the potential safety risk for hydrogen storage, evaluate storage integrity for different geological storage options, and support safe operations through industrial standards and emerging technologies.

CEC Question: Recommendations on research approaches?

The CHBC recommends the CEC begin by researching long-term hydrogen storage in depleted oil fields by researching pilots from other states and countries who have tested the same or similar projects. It is essential the CEC does not reinvent the research process where other states or countries have already established a process that yielded positive results.

CEC Response:

The CEC will consider publicly available research results pertaining to geologic hydrogen storage in solicitation development. CEC staff will conduct workshops and collaborate with stakeholders to identify and further refine research priorities.

Comment Received from: NFCRC

CEC Question: What are the promising use cases and suitable geological storage opportunities in California?

Salt caverns are already widely used and proven and as a storage facility for hydrogen. Results of both daily and seasonal simulation conducted by UC Irvine suggest that with the same size wind farm and salt cavern, a compressed hydrogen energy storage system could better complement the wind intermittency and could also achieve load shifting on a daily and seasonal time scale.1 Air Liquide and Praxair have been operating salt cavern hydrogen storage in Texas since 2016. These massive energy storage facilities have a very low leakage rate and represent safe and low-cost storage. Europe has had similar success in using salt cavern storage.

Magnum Development is bringing together a Western Energy Hub ("WEH") site located adjacent to the Intermountain Power Project ("IPP") in Millard County, Utah, that:

> …can serve as a foundation of the Sustainable City Plan for Los Angeles, Southern California, and the Western region. This regional platform, with ready access to Southern California energy and transportation markets, offers a unique combination of geography, geology, energy and transportation infrastructure, and renewable energy resources that can serve to rapidly deploy new clean energy technologies and practices at commercial scale—meeting regional needs and speeding clean energy adoption and use worldwide. The unique combination of resources and infrastructure makes the WEH site an exceptional platform for the development of a regional clean energy hub serving both power and transportation markets. The potential exists to use the massive and

unique salt cavern resource to store wind and solar energy in the forms of hydrogen and compressed air and to access greater Los Angeles energy and transportation markets via a 2,400 MW, 500 kV direct-current transmission line, as well as major rail and highway routes for moving hydrogen to regional transportation markets.

Recent studies in Europe have begun to produce results for the investments required to transform their current depleted oil and gas fields into renewable hydrogen energy storage facilities. Some research and development to explore similar research and development for California depleted oil and gas storage facilities is merited.

CEC Response:

Both salt caverns and depleted oil and gas storage facilities are considered as part of the geological storage research initiative. Even though salt caverns have been widely used by the industry, the data from the U.S. Energy Information Administration shows California has no capacity for salt cavern storage. There is considerable capacity for depleted gas storage, which will be considered as an option in this proposed research initiative.

CEC Question: What types of requirements should inform geological storage decision-making?

Depleted oil and gas fields in California could also potentially be used for hydrogen storage, if some critical research and development in the following areas is completed:

- Hydrogen leakage
- Hydrogen reaction with petroleum remnants
- Hydrogen biological interactions
- Hydrogen storage capacity
- Hydrogen safety

This research should be followed by pilot testing of hydrogen injection into depleted oil and gas fields with a detailed and robust measurement and verification testing plan.

CEC Response:

All above requirements are considered in the research imitative. The current research initiative will not conduct pilot testing of injection into gas storage fields, which may be considered for future research.

CEC Question: Recommendations on research approach(es)?

- Invest in R&D to determine whether and how current CA facilities can be transformed to store large amounts of hydrogen.
- Even small percentages of hydrogen injection into the natural gas system (e.g., 5-10% by volume) could provide a massive resource for supporting very high renewable use in the electric grid.
- Investigate challenges to hydrogen injection and conversion throughout the infrastructure by holding hydrogen to and hydrogen natural gas mixtures to standards of gas infrastructure.

- Investigate hydrogen leakage phenomena. A recent study shows that hydrogen may leak at the same rate as natural gas in typical low-pressure gas infrastructure, but much more needs to be done.
- Encourage regulation and policies at CARB and sister agencies to expedite the formulation and adoption of pipeline hydrogen injection standards
- Investigate the subsequent piecewise transformation of gas infrastructure to 100% renewable hydrogen.

CEC Response:

The comments and recommendations about research approaches will be taken into consideration in the future solicitation for geological storage or future hydrogen research plans.

Comment Received from: SoCalGas

CEC Question: What are the promising use cases and suitable geological storage opportunities in California?

A large-scale hydrogen transportation and storage network does not currently exist in California. Utilizing the existing natural gas grid to transport hydrogen through blending in addition to building out a dedicated hydrogen pipeline network could encourage long-term, inter-seasonal storage of hydrogen, support renewable generation optimization, and increase energy grid resiliency. There is a distinct value proposition for policymakers to support hydrogen infrastructure development by implementing hydrogen policies to scale the adoption of hydrogen energy storage, which would then drive down costs. SoCalGas' Clean Fuels Report describes the detailed buildout of a potential clean fuels network in Southern California.6 As depicted in Figure 1 (below), a clean fuels transmission backbone system has the potential to serve thermal generators, trucking routes, and match industrial hydrogen demand with hydrogen supply. When handling substantial hydrogen volumes, "[m]ultiple natural gas transmission pipelines would need to either blend hydrogen alongside natural gas or be retrofitted for hydrogen transport."

Further, a recent Bloomberg NEF report, "Hydrogen: The Economics of Storage," evaluated eight major hydrogen storage technologies that can be utilized today. The report found that rock caverns are "[t]he next best large-scale storage solution in locations without salt caverns, as they have the potential to store hydrogen for $0.71/kg, which [researchers] postulate could fall to $0.23/kg if abandoned tunnels or mines can be used."9 The report also found that depleted oil and gas fields "could be especially good at storing large volumes for long periods."10 Table 1 (below) shows the different storage options of which five are in current use and three are being further explored.

CEC Response:

Hydrogen remains a priority research area given the noted broad applications and research needs, with the current gas initiatives on decarbonization of gas end uses.

Initiative Title: Industrial Clusters for Clean Hydrogen Utilization

Comment from National Fuel Cell Research Center:

CEC Questions: What are key criteria when determining what industries to cluster and where? What California industries would benefit most from clustering of hydrogen infrastructure? Are there relevant examples of similar clustering efforts nationally or internationally? What are some resources that can help inform this research initiative? What approaches should be considered when deploying hydrogen infrastructure?

National Fuel Cell Research Center Response:

- Policymakers and regulators have analyzed the features that are needed to meet zero emissions policy goals and are developing hydrogen strategies, investing in hydrogen demonstration projects and R&D and laying the groundwork for green hydrogen production, storage, transport, and conversion.
- Japan, Germany, United Kingdom, and Canada have developed formal hydrogen roadmaps and are implementing a range of industrial policies to enable green hydrogen.
- In November 2021 the U.S. included $9.5 billion in the Infrastructure Investment and Jobs Act (IIJA) with $8 billion of the funding targeted at regional hydrogen hubs to demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen.
    - Green hydrogen has been identified by New York Governor Hochul as critical to the State's energy transition including making New York a green hydrogen hub. NYSERDA Hydrogen Innovation Funding $27M including product development, pilots, and demonstrations w/federal FOAs, green hydrogen prize, and truck and bus vouchers.
- UCI has several hydrogen related projects focusing on the relationship between higher blends of hydrogen and emissions reductions.

CEC Response:

Thank you for the feedback. Staff will track these projects as the results from these projects may inform future solicitation development for industrial hydrogen clustering.

Comment from California Hydrogen Business Council (CHBC):

CEC Questions: What are key criteria when determining what industries to cluster and where? What California industries would benefit most from clustering of hydrogen infrastructure?

CHBC Response:

- Key criteria include the number of industries to be co-located, the most promising locations, the industrial sectors most compatible for regional hydrogen deployments in California, and safety for neighboring communities—are the location of hydrogen production plants, the hydrogen refueling infrastructure necessary to support the transport of hydrogen, the hydrogen gas distribution infrastructure location and needed improvements, and the local air pollutant reduction potential within a hydrogen cluster.

- The industries that would benefit include cement production, steel production, ammonia production, chemical production, and light and heavy-duty transportation.

CEC Response:

Staff appreciates your feedback and will consider CHBC's comments and recommendations for industrial hydrogen clustering opportunities in future solicitation development.

Comment from Southern California Gas:

CEC Question: What are key criteria when determining what industries to cluster and where? What California industries would benefit most from clustering of hydrogen infrastructure? Are there relevant examples of similar clustering efforts nationally or internationally? What are some resources that can help inform this research initiative? What approaches should be considered when deploying hydrogen infrastructure?

Southern California Gas Response:

Key criteria include industry composition, geographical location, existing infrastructure, energy costs and policy, and technology landscape are key criteria to consider when determining which industries to cluster and when deciding on a location. Port decarbonization can greatly benefit from a cluster approach for hydrogen infrastructure.

- Relevant examples of national and/or international clustering efforts
    - CEC should support inclusive clean hydrogen efforts and seek to promote ways California can facilitate federal efforts to accelerate research, development, demonstration, and deployment of hydrogen from clean energy sources.
    - Humber industrial cluster in Yorkshire is the United Kingdom's (U.K.'s) largest cluster by industrial emissions, emitting 10 million tons of CO2 per year. Zero Carbon Humber aims to establish the world's first net-zero industrial cluster by 2040 via the creation of CCS infrastructure and the production of blue and green hydrogen.
    - Majorca Green Hydrogen, Power-2-Green Hydrogen, project aims to pioneer a solution for island GHG emissions reduction and industrial reconversion on the island of Majorca, Spain to include the public transportation fleet; green hydrogen injected into the gas grid to supply industrial parks and as backup energy for buildings.
- Approaches to be considered include system value impact with a focus on environmental justice and equity; integrated energy system design; building a coalition of key stakeholders; demand aggregation; and ensuring commercial viability through innovative public-private mechanisms.
- Additional resources include, but are not limited to: Frontier Economics Business Models for Low Carbon Hydrogen Production, World Economic Forum & Accenture Industrial Clusters Report, World Economic Forum System Value Report, The Future of Clean Hydrogen in the United States: Views from Industry, Market Innovators, and Investor, Evaluating Net-Zero Industrial Hubs in the United States and Humber Energy Intensive Industries Report.

CEC Response:

Thank you for the information. The CEC staff will continue to monitor national and international industrial clustering efforts to appropriately inform future solicitation development. The comments and recommendations will be taken into consideration in future solicitation for industrial hydrogen clustering opportunities.

Initiative Title: Mitigate Criteria Air Pollutants in Hydrogen-Based Power Generation

Comment from SoCalGas:

CEC Questions: What are the most promising energy innovations that could drive down the cost of mitigation technologies? And what types of demonstrations are needed to expand deployment of these technologies in the future?

- **SoCalGas Response:** SoCal Gas provided citations for the following RD&D projects:
  - UCI Effect of Hydrogen Addition into Natural Gas on SCR of NOx Lab Testing
  - UCI Fuel Flexible Microturbine Generator Development
  - UCI Fuel Flexible Rotary Engine MicroCHP Development
  - Data collection from these demonstrations will help us better understand the relationship between higher blends of hydrogen and emissions reductions.

CEC Response:

The project descriptions provided are consistent with the proposed initiatives. Staff will track these projects as the results from these projects may inform future solicitation development.

Comment from California Hydrogen Business Council:

CEC Questions: What are the most promising energy innovations that could drive down costs of mitigation technologies? What are suggested target metrics for the mitigation technologies? What types of demonstrations are needed to expand deployment of these technologies in the future? Are there technology development opportunities to accommodate both higher blends of hydrogen and emission reductions simultaneously?

- **CHBC Response:** More detail is needed for a proper response, and it is unclear what is meant by "mitigation technologies." As a trade association, CHBC is agnostic to particular configurations and technology solutions. However, the CHBC recommends the CEC choose the technologies that lend themselves to a low or zero carbon intensity score. A carbon intensity score captures the lifecycle emissions of a fuel with a metric of carbon emissions as compared to diesel and gasoline. Hydrogen, on a carbon intensity score, can have as low as -105 carbon intensity to as much as 70 carbon intensity depending on the production feedstock and process. Pinpointing a carbon intensity metric as a basis for eligibility creates competition of fuel producers that drives down costs and engenders innovation as fuel producers work to meet decarbonization targets.

CEC Response:

Mitigation technologies are technologies that can reduce NOx emissions due to combusting high percentages of hydrogen and can be used before, during, or after combustion. Examples of these technologies are included in the initiative. Regarding carbon intensity, this initiative builds off last year's initiative, titled "Developing and Demonstrating Hydrogen-based Power Generation Systems," which aims to blend low-carbon hydrogen into the fuel mixture of gas generators. Further clarification of low-carbon hydrogen may be included in the resultant solicitation.

Comment from National Fuel Cell Research Center:

CEC Question: What are the most promising energy innovations that could drive down cost of mitigation technologies?

- **National Fuel Cell Research Center Response:** It is premature for the CEC to assume that hydrogen categorically increases emission. When used in non-combustion fuel cell systems, hydrogen produces no emissions. In addition to fuel cell technology there is burner design, all these things we do with gasifiers. Research should be conducted on combustion design and aftertreatment.

CEC Response:

This research initiative aims to mitigate NOx emissions, and potentially other criteria air pollutants, such as carbon monoxide, from the combustion of a high percentage of hydrogen in power generation applications. The initiative will not include non-combustion fuel cell systems. Non-combustion fuel cell systems are included in the proposed the Electric Program Investment Charge Investment Plan[1] as they relate to electricity generation. CEC agrees with the suggestion to conduct research on combustion design and aftertreatment and has included examples in the research initiative.

Initiative: Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Comment Received from: NFCRC

CEC Question: How beneficial is the funding augmentation approach for potential applicants?

There is no reason that the CEC should limit the discussion of hydrogen refueling infrastructure to heavy-duty transport. Hydrogen is more efficient for long trips, long time to store electricity. Hydrogen infrastructure can serve many customers with a very small footprint. Infrastructure investment and total cost of ownership is cheaper for hydrogen vehicles.

[1] Electric Program Investment Charge Proposed 2021-2025 Investment Plan: EPIC 4 Investment Plan. California Energy Commission. https://www.energy.ca.gov/publications/2021/electric-program-investment-charge-proposed-2021-2025-investment-plan-epic-4

CEC Response:

Due to limited funds, the Gas R&D Program prioritizes research in specific sectors. While the CEC's Clean Transportation Program has invested in deployment of a hydrogen refueling station network for light-duty vehicles using commercially available technology, research gaps exist for emerging hydrogen refueling solutions dedicated for heavy transport applications. The proposed initiative aims to address these gaps through research and technology development to further improve the feasibility of adopting hydrogen fuel cells for heavy transport.

Comment Received from: CHBC

CEC Question: Are there additional barriers or innovations that should be targeted or prioritized?

A barrier to wide-scale hydrogen refueling infrastructure for heavy transport is the lack of a set heavy-duty station goal and funding to support that goal. To ensure California's meets its air quality and decarbonization goals, it is critical the medium-and-heavy duty vehicles in the state are transitioned to zero-emission vehicles like fuel cell electric vehicle (FCEV) trucks and busses. The CHBC seeks a statewide goal of 200 heavy-duty hydrogen fueling stations by 2035 and the implementation of Hydrogen Refueling Infrastructure (HRI) credits for heavy-duty stations. The 200 heavy-duty hydrogen fueling station goal can be met if the HRI credits fund receives an additional 2.5% deficit allotment and an increase in the Low Carbon Fuel Standard (LCFS) program's credit capacity of 1,200 kilograms of hydrogen per day. The CHBC proposes a capacity increase that reflects the quantities of hydrogen needed to support the 70,000 heavy-duty FCEVs that will be utilizing the 200 heavy-duty hydrogen fueling stations.

CEC Response:

CEC staff will consider the initiative's role in mitigating barriers to achieve new statewide goals and informing updates to the Low Carbon Fuel Standard during solicitation development.

CEC Question: What recommendations do you have on research approaches or performance metrics to target?

The CHBC recommends the CEC adopt the same performance metrics as the LCFS program administered by the California Air Resources Board (CARB).

CEC Response:

CEC staff will leverage performance metrics used by the Low Carbon Fuel Standard program where relevant during solicitation development.

CEC Question: How beneficial is the funding augmentation approach for potential applicants?

An increase in funding, an established 200 station goal, the creation of a separate HRI credit program for heavy-duty hydrogen refueling stations, and an increase in the LCFS capacity credit are critical to send the correct market signals to hydrogen station developers that their investment will result in commercialization of their product. California's agencies must work together in a holistic approach to decarbonization of the heavy transport sector.

CEC Response:
CEC staff will continue to coordinate with the Clean Transportation Program, CARB, GO-Biz, and other agencies involved in the deployment of heavy-duty hydrogen refueling stations to ensure the solicitation complements related efforts.

Comment Received from: SoCalGas

CEC Question: What recommendations do you have on research approaches or performance metrics to target?

In November of 2021, the Energy Commission approved a plan for $1.4 billion to help speed up the state's zero-emission vehicle infrastructure build-out. In addition, SoCalGas understands that the Governor is proposing to inject an additional $6.1 billion, building upon last year's investment of $3.9 billion in zero-emission vehicles, to accelerate the statewide transition to ZEVs, including hydrogen refueling infrastructure. We support this activity; however, it is unclear how a subset of the already limited PIER NG $24 million annual budget for similar projects will fund what the multi-billion-dollar funding will not. To provide clarity and certainty for these foundational projects intended to accelerate ZEV adoption, we recommend the Energy Commission's Fuels and Transportation Division fund these types of activities, rather than through the PIER NG program at this time.

CEC Response:
CEC staff is coordinating internally between the Gas R&D Program and the Clean Transportation Program. While the CEC Fuels and Transportation Division's Clean Transportation Program is focused on deployment of commercial charging and refueling infrastructure technologies to reduce emissions from on-road vehicles, the Gas R&D Program prioritizes research and technology development that complement these deployment efforts by advancing refueling station technology that will improve performance and lower costs for dispensed hydrogen.

The $1.127 billion of General Fund monies included in the 2021-2023 Investment Plan Update for the Clean Transportation Program prioritizes diesel emission reduction with funding to replace 1,125 drayage trucks, 1,000 school buses, and 1,000 transit buses with zero-emission alternatives and provide supporting refueling infrastructure. The proposed research initiative covers hydrogen refueling infrastructure advancements beyond commercially available technology across a broader definition of heavy transport, which also includes off-road agricultural and construction equipment, cargo handling equipment, and rail and marine.

The CEC will continue monitoring the status of California's 2022-23 state budget to appropriately prioritize complementary initiatives and avoid duplication across programs.

Initiative Theme: Entrepreneur Development

Initiative: CalSEED

Comment Received from: SoCalGas

In this section, we answer: What technologies are being developed by start-ups that can support safe decarbonization of existing uses of fossil gas?

SoCalGas Comment #1: We suggest that the CEC consider supporting funding competitions to increase innovation. For example, SoCalGas has been a long-time sponsor of Caltech's Rocket Fund, which helps academic and garage innovators turn their technologies into commercial realities through financial support and entrepreneurial mentoring and education.

CEC Response:

This initiative will build on the proven success of the EPIC-funded CalSEED program. Each year, CalSEED receives between 200 and 400 applications, of which only 25-28 are selected for a CalSEED award. This oversubscription shows not only the popularity of the program, but also the lack of alternative funding opportunities at this early stage. This initiative will fill gaps in the CalSEED program for technologies that can help decarbonize the gas sector and improve the safety and resiliency of gas infrastructure. In addition, this initiative will leverage the existing CalSEED program by having the same administrator manage both EPIC and gas funding portions; enabling the CEC to take advantage of operational efficiencies and reduce duplicative efforts and activities that would occur if the two programs were administered by separate entities. This includes labor-intensive activities such as: conducting outreach to clean energy entrepreneurs in disadvantaged and low-income communities and rural locations in the state; setting up meetings between potential investors and the start-up companies; and standard administrative activities.

The CEC and CalSEED actively collaborate and support other entities fostering early-stage innovation including the Rocket Fund, the Los Angeles Cleantech Incubator, and Cleantech San Diego, among others. These efforts create a robust ecosystem of support for California clean energy entrepreneurs, providing resources and support at various stages of technology and market maturity.

SoCalGas Comment #2: Further, SoCalGas suggests that the California Sustainable Energy Entrepreneur Development Initiative (CalSEED) include Diversity, Equity, and Inclusion (DE&I) provisions so that entrepreneurial development resources reach traditionally underserved communities. We recommend connecting with community-based organizations (CBOs) in disadvantaged communities and reaching out to diverse colleges and universities, such as California State University, Los Angeles and California State University, Long Beach. CalSEED should develop metrics and reporting to demonstrate to the public stakeholders that funding and development resources are reaching communities that are diverse with respect to race, gender, geography, and socioeconomics.

CEC Response:

As mentioned in the prior response, this initiative will be modeled after and leverage the successful CalSEED program including CalSEED's emphasis on DE&I. The following describes some of the steps the CEC and CalSEED administrator have taken to ensure DE&I is core to CalSEED under EPIC and will be mirrored in the gas portion of CalSEED:

- CalSEED has an Advisory Committee that provides guidance and input on DE&I.
- Equity and impact are significant parts of the scoring criteria used to select start-up companies for CalSEED.
- CalSEED has a minimum funding target for diverse businesses such as minority-, women- and lesbian, gay, bisexual, transgender, queer (LGBTQ)-owned businesses, as well as for businesses in a disadvantaged community or rural part of the state.

- CalSEED evaluates and select proposals based on their geographic region in California. This ensures geographic diversity of CalSEED recipients.
- CalSEED provides mentoring to clean energy start-up companies on how they can make equity part of their businesses' core values as they grow and scale.
- CalSEED conducts outreach to clean energy entrepreneurs from diverse and underrepresented backgrounds. This has included commercials broadcast on Spanish-speaking radio stations.

DACAG and CEC Staff Coordination Meeting

The CEC presented the draft FY 2022-23 Gas R&D Program Budget Plan to representatives of the DACAG at a meeting on January 13, 2022. At the meeting, CEC staff presented an overview of the Gas R&D Program and development process and summaries of the seven proposed initiatives included in the draft FY 2022-23 Gas R&D budget plan. The CEC appreciates the helpful questions and comments from DACAG members on the draft FY 2022-23 Gas R&D budget plan. Below is a summary of DACAG member comments and CEC staff responses organized by initiative.

1. **Scaled-up Gas Decommissioning Pilots and Integrated Planning Tools**
   - DACAG members sought clarity on the equity considerations of this initiative and AB 3232. CEC staff clarified that the initiative will evaluate the distribution of expenses and benefits related to gas decommissioning to meet the state's building decarbonization goals.

2. **Large-volume Hydrogen Storage for Targeted Use Cases**
   - No comments.

3. **Industrial Clusters for Clean Hydrogen Utilization**
   - CEC staff addressed questions to clarify initiative benefits related to analyzing industrial pollutant emission reduction strategies, technical feasibility issues, and safety hazards.

4. **Mitigating Criteria Air Pollutants in Hydrogen-Based Power Generation**
   - No comments.

5. **Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport**
   - CEC staff clarified the broad list of priority end-uses defined under the initiative. This is intended to keep the solicitation open to various market sectors and attract a larger number of proposals.
   - DACAG members sought clarity on the equity benefits of the initiative and provided opportunities to leverage the AB 617 steering committee for solicitation outreach. CEC staff clarified that preference points will be included in the solicitation for proposals that benefit disadvantaged communities and low-income communities.

6. **Analysis of Residential Hot Water Distribution Designs**
   - No comments.

7. **CalSEED – Low-Carbon Gas**

- No comments.

FY 2022-23 GAS R&D Initiatives

Energy Research and Development Division

Agenda – Session I

Approximate Time	Item
9:00 am	Welcome and Overview
9:10 am	Session I: Staff Presentations on Proposed Initiatives • Targeted Gas System Decommissioning • Decarbonization of Gas End Uses • Energy Efficiency • Entrepreneur Development
10:00 am	Session I: Questions and Discussion
10:55 am	5-minute break

Agenda – Session II

Approximate Time	Item
11:00 am	Session II: Contractor (Guidehouse) Presentation
11:40 am	Session II: Questions and Discussion

Announcements

- This workshop is being recorded and will be posted at: https://www.energy.ca.gov/event/workshop/2022-01/gas-rd-workshop
- Gas R&D Budget Plan documents and workshop materials, including this presentation, will be posted at: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=16-PIER-01
- Participants will be muted during the presentation.
- Please type your comments and questions in the Q&A window.
- Sign up for updates on the "naturalgas" or "research" Listserv: https://ww2.energy.ca.gov/listservers/index_cms.html

Session I

California Energy Commission

FY 2022-23 Proposed Gas R&D Initiatives

Introduction

- Research and development to support the transition to clean energy, greater reliability, lower costs, and increased safety for Californians
  - Benefits California citizens, and
  - Not adequately addressed by competitive or regulated entities
- $24 million annual budget, funded by a surcharge on gas consumption in California

Gas R&D Program

- Focus on energy efficiency, renewable technologies, conservation, and environmental issues.
- Supports state energy policy.

Developing Initiatives

Informed by:

- Gas R&D Objectives
- CPUC Resolutions
- Equity considerations
- Discussion with stakeholders
  - Docket: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=16-PIER-01

State Energy Policy Drivers

- **SB 32 (2016)**
  - Reduce GHG emissions to 40% below 1990 levels by 2030.
- **EO B-55-18**
  - Establishes statewide goal to achieve carbon neutrality as soon as possible and no later than 2045.
- **Integrated Energy Policy Report**
  - Policy recommendations that conserve resources, protect the environment, ensure energy reliability, enhance the state's economy, and protect public health and safety

CPUC Resolution G-3584

- Consider the findings from the Assembly Bill 3232 (Friedman, 2018) report.
- Consider the findings from the initiative: *Long-Term Technological Development Strategy to Meet Aggressive Statewide Decarbonization Goals*.

Diversity & Equity Commitment

To meet CECs commitment to diversity and equity, Energy Commission staff:

- Engage with disadvantaged and underrepresented groups throughout the state.
- Improve CECs application and grant management process to relieve administrative burdens.
- Continue to advance efforts in underresourced communities.

FY 2022-23 proposed research initiatives are framed around ***decarbonization***.

Initiative Themes:

- Targeted Gas System Decommissioning
- Decarbonization of Gas End Uses
- Energy Efficiency
- Entrepreneur Development

Initiative Theme: Targeted Gas System Decommissioning

Scaled-up Gas Decommissioning Pilots and Integrated Planning Tools

Presenters: Qing Tian & Susan Wilhelm

Scaled-Up Gas Decommissioning Pilots and Integrated Planning Tools

Purpose: Design a large-scale gas system decommissioning pilot and enhance a data-driven tool for identifying promising decommissioning sites and supporting gas system planning. Results will facilitate cost-effective, safe, and equitable decarbonization that is informed by community perspectives and priorities.

Background

- Replacement costs and stranded assets associated with aging gas infrastructure.
- Number of customers expected to decline in gas system transition
- Strategic planning enables meeting decarbonization goals while containing cost and addressing equity and safety concerns
- Informed by ongoing CPUC-CEC coordination

Innovations

- Design a large-scale pilot for decommissioning segments of the gas system that delivers cost, environmental, health, and equity benefits.
  - Collect data on infrastructure condition, capacity for electrification, etc.
  - Assess opportunities for gas system pruning and implications for operation of the remaining system.
  - Under-resourced communities will be prioritized in site selection.
  - Leverage insights from stakeholders and previous work.
- Enhance a data-driven tool to support gas system planning.
  - Facilitate planning across a range of time horizons.
  - Consider cost impacts of gas and electricity system interactions.
  - Analyze potential roles of emerging zero-carbon energy sources.
  - Assess consumer and community-level energy choices.

Benefits

- **Safety:** Address aging infrastructure and limit stranded assets.
- **Affordability:** Manage costs and rates throughout the transition.
- **Environmental Sustainability:** Decrease end-use emissions, methane leakage, and health impacts from in-home pollution from gas appliances.
- **Equity:** Reduce costs to vulnerable communities and others.

Questions for Stakeholders

1. What emerging zero-carbon fuels should be considered by the planning tool?
2. What are potential challenges to large-scale pilots?
3. What are the best practices in customer engagement on gas-to-electricity transition?
4. What are the recommendations on minimizing cost impacts and supporting equity?

Topic Area: Decarbonization of Gas End Uses

Large-volume Hydrogen Storage for Targeted Use Cases

Presenter: Qing Tian

Large-volume Hydrogen Storage for Targeted Use Cases

Purpose: Assess technical and cost feasibility and inform decision-making to support the safe and efficient implementation of geological hydrogen storage in California for targeted use cases.

Background

- Hydrogen is a potential low carbon fuel replacement for fossil gas for dispatchable power generation and high-temperature industrial processes.
- Geological storage may be a low-cost solution with significant storage capacity but requires research on safety and economic performance.
- Proposed research will inform greenhouse gas emission reduction strategies.

Innovations

- Identify main options for the geological storage of hydrogen in California that match the needs of hydrogen industry applications.
- Investigate the technical requirements and collect operational and techno-economic insights for large-volume, geological storage opportunities.
- Develop mitigation strategies associated with technical and operational risk and evaluate emerging technologies to enable safe and reliable hydrogen storage.

Ratepayer Benefits

- **Safety:** Support the safe operation of geologic hydrogen storage.
- **Affordability:** Identify cost-effective storage options at scale, leading to stable and affordable costs for consumers.
- **Environmental Sustainability:** Facilitate renewable hydrogen usage in California for hard-to-decarbonize applications.

Questions for Stakeholders

1. What are the promising use cases and suitable geological storage opportunities in California?
2. What types of requirements should inform geological storage decision-making?
3. Recommendations on research approach(es)?

Industrial Clusters for Clean Hydrogen Utilization

Presenter: Ilia Krupenich

Industrial Clusters for Clean Hydrogen Utilization

Purpose: Identify and characterize optimal co-location of industries ("clusters") to share hydrogen infrastructure. Considerations include the number of industries to be co-located, the most promising locations, the industrial sectors most compatible for regional hydrogen deployments in California, and safety for neighboring communities.

Background

- Renewable hydrogen can decarbonize high-temperature industrial processes, which accounts for approximately 20 million metric tons of carbon dioxide equivalent emissions per year.
- High production and transportation costs for hydrogen could be alleviated by strategic sharing of hydrogen infrastructure.
  - Accelerate learning
  - Reduce capital costs
  - Improve economies of scale
  - Leverage beneficial by-products

Innovations

- Evaluate technical advancements needed for using hydrogen in industrial applications.
- Identify potential locations for clustering hydrogen-using industrial facilities and engage stakeholders to identify, demonstrate, and assess opportunities.
- Identify the feasibility and cost savings opportunities from repurposing segments of existing gas infrastructure compared to new infrastructure.

Ratepayer Benefits

- **Affordability:** Drive down the cost of hydrogen, making it more affordable for industries to reduce greenhouse gas emissions.
- **Environmental Sustainability:** Replacing fossil gas with renewable hydrogen could reduce greenhouse gas and criteria air pollutant emissions.
- **Equity:** Examine strategies for ensuring safety, lowering pollution burden, and providing economic opportunities for local communities.

Questions for Stakeholders

1. What are key criteria when determining what industries to cluster and where?
2. What California industries would benefit most from clustering of hydrogen infrastructure?
3. Are there relevant examples of similar clustering efforts nationally or internationally?
4. What are some resources that can help inform this research initiative?
5. What approaches should be considered when deploying hydrogen infrastructure?

Mitigate Criteria Air Pollutants in Hydrogen-Based Power Generation

Presenter: Kaycee Chang

Mitigate Criteria Air Pollutants in Hydrogen-Based Power Generation

Purpose: Mitigate criteria air pollutants from the combustion of high hydrogen blends in power generation applications.

Background

- Hydrogen-based generation technologies can reduce the consumption of fossil gas and its emission footprint.
- Building on FY 2021-2022 hydrogen-blending initiative to further focus on emissions from power generation technologies that can run efficiently on high blends of hydrogen.
- Emissions from combustion-based generation can disproportionately impact local communities.
- Adapting existing NOx reduction methods to work with hydrogen blends has technical challenges especially as the hydrogen percentage is increased.

Innovations

- Improve stationary system pre-intake and combustor control strategies (e.g., optimizing air fuel ratio, integrating water and steam injection).
- Improve aftertreatment technologies (e.g., improving catalyst design and performance).
- Measure and quantify air quality improvements and public health benefits of adopting advanced pollutant mitigation technologies.

Ratepayer Benefits

- **Affordability:** Increase market adoption of high hydrogen blends and reduce the cost of air quality mitigation in hydrogen power generation.
- **Environmental Sustainability:** Support the adoption of hydrogen blends in the fuel mixture of gas systems, potentially reducing statewide consumption of fossil gas in power generation.
- **Equity:** Improve air quality in under-resourced communities by decreasing criteria air pollutants emissions generated from hydrogen combustion.

Questions for Stakeholders

1. What are the most promising energy innovations that could drive down cost of mitigation technologies?
2. What are suggested target metrics for the mitigation technologies?
3. What types of demonstrations are needed to expand deployment of these technologies in the future?
4. Are there technology development opportunities to accommodate both higher blends of hydrogen and emission reductions simultaneously?

Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Presenter: Peter Chen

Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Purpose: Improve the cost effectiveness and performance of hydrogen refueling infrastructure technologies for heavy transport:

- Heavy-duty trucks
- Off-road agricultural and construction equipment
- Cargo handling equipment
- Rail and marine (at ports and other in-state facilities)

Augment the FY2021-22 transportation initiative with additional funds.

Background

- Adoption of hydrogen fuel cells as a zero-emission alternative for heavy transport is limited by the lack of a robust hydrogen refueling infrastructure network in California.
- R&D can address performance, cost, and logistical barriers such as:
  - High delivery and refueling costs
  - Reliability
  - High flow rates for fast refueling of larger vehicles
  - Lack of practical access to typical on-road refueling stations for off-road, rail, and marine applications
- Bridge the technology gap between DOE's low technology readiness level (TRL) research and CEC's Clean Transportation Program investments in high TRL deployments.

Innovations

- Improve efficiency and reliability of station components and designs:
  - Advanced compressors, cryopumps, and chillers;
  - Innovative configurations to reduce footprint and increase utilization;
  - Integrated on-site renewable hydrogen production.
- Develop high flow rate systems to support public access heavy-duty truck stations and larger rail and marine applications.
- Address barriers to enabling high capacity, flexible hydrogen mobile refueler solutions.

Ratepayer Benefits

- **Affordability:** Reducing costs of delivering and refueling hydrogen will lower the price of hydrogen at the pump for transportation end uses.
- **Environmental Sustainability:** Improving the feasibility of adopting hydrogen fuel cells for heavy transport will lead to greenhouse gas and air pollutant emission reductions.
- **Equity:** Accelerating a transition to zero-emission alternatives for heavy transport will benefit under-resourced communities located near ports, rail yards, warehouses, and highways.

Questions for Stakeholders

1. Are there additional barriers or innovations that should be targeted or prioritized?
2. What recommendations do you have on research approaches or performance metrics to target?
3. How beneficial is the funding augmentation approach for potential applicants?

Initiative Theme: Energy Efficiency

Analysis of Residential Hot Water Distribution Designs

Presenter: Amir Ehyai

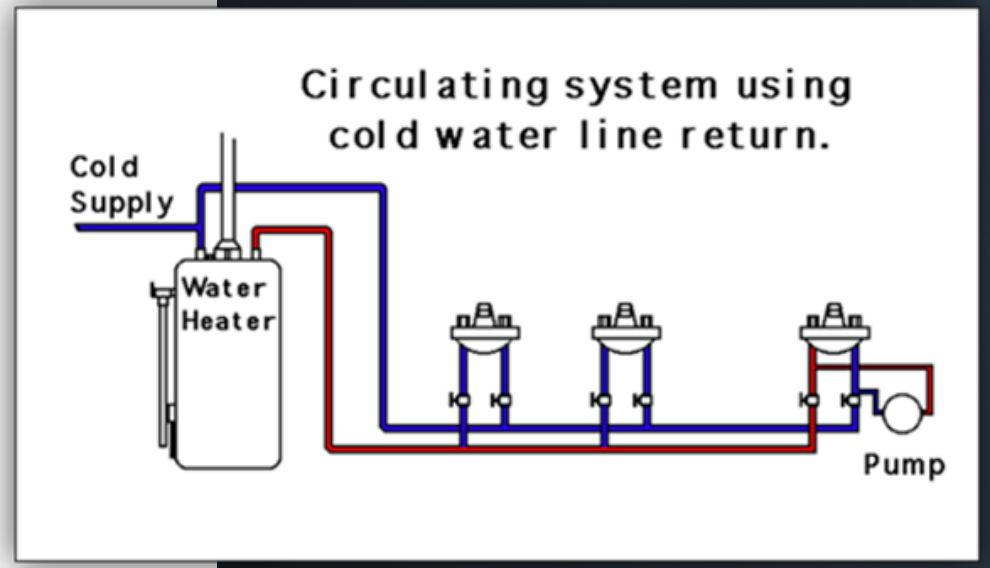
Analysis of Residential Hot Water Distribution Designs

Purpose

- Identify technological advancements to on-demand hot water recirculation system, such as use of smart controls and electronically commutated motors, to reduce energy and water use in existing and new single-family homes.
- Demonstrate real-world energy and water savings.
- Inform future energy code.

Background

- Research on hot water recirculation systems is dated.
- Many circulator pumps currently sold on the market are uncontrolled continuous recirculation pumps.
- Other sales are timer-based which typically operate 16 hours per day.
- On-demand circulator pumps offer similar convenience and water-saving benefits and save substantial energy compared to standard models.
- On-demand models make up less than 5% of sales.



Innovations

- Identify technological advancements for on-demand recirculation systems that can reduce energy and water use compared to standard systems.
- Demonstrate technically advanced recirculating systems on various water heater types in new and existing single-family homes.
- Compare value proposition of advanced recirculating systems to other water and energy saving distribution designs.
- Provide technical and economic data to inform changes to appliance standards and energy code.

Ratepayer Benefits

- **Affordability:** On-demand circulator pumps are an easy and cost-effective retrofit option and have an expected useful life of 15 years.
- **Environmental Sustainability:** Recirculation systems can save an estimated 1,100 gallons of water per person annually; and when compared to continuous operation, demand activated pumps can save significant electricity and natural gas.

Questions for Stakeholders

1. What research is needed to reduce cost of on-demand circulator pumps?
2. Are there technological advancements to increase uptake of on-demand recirculation systems?
3. How can research overcome any technical limitations to use of these devices on heat pump water heaters, tankless and other water heaters?

Topic Area: Entrepreneur Development

California Sustainable Energy Entrepreneur Development (CalSEED) - Low-Carbon Gas

Presenter: Michael Ferreira

CalSEED – LCG

Purpose: Provide entrepreneurs starting capital to develop their ideas into proof-of-concepts to decarbonize existing uses of fossil gas by funding the recently-established CalSEED-Low-Carbon Gas program.

Background

- Modeled after EPIC-funded CalSEED program, administered by New Energy Nexus.
- CalSEED receives 200 – 400 applications annually with only 25-28 selected for award.
- 91 start-ups have received $37 million in public funding and $28 million in private investment.
- 2017 CalSEED recipient Cuberg received subsequent investment from NSF, U.S. Army, U.S. Air Force, Boeing. Acquired by Northvolt in 2021.

Innovations

Technology areas of focus may include carbon capture; hard-to-electrify end-uses such as industrial process heating and medium- and heavy-duty transportation and producing low-carbon alternatives to fossil gas such as green hydrogen and biogas.

Ratepayer Benefits

- **Safety:** Projects developing innovations to improve gas pipeline safety, including solutions that can predict, detect, and repair infrastructure threats and vulnerabilities.
- **Affordability:** Projects developing innovations that can cost-effectively decarbonize existing uses of fossil gas.
- **Environmental Sustainability:** Improved air quality from the development of fossil gas alternatives.

Questions for Stakeholders

1. What technologies are being developed by start-ups that can support safe decarbonization of existing uses of fossil gas?
2. What intellectual property is being developed at research institutions to support safe decarbonization of the fossil gas sector that is ready to spin out into commercial ventures?

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: Session I
Proposed Research Initiatives

Targeted Gas System Decommissioning

- Scaled-Up Gas Decommissioning Pilots and Integrated Planning Tools

Decarbonization of Gas End Uses

- Large Volume Hydrogen Storage for Targeted Use Cases
- Industrial Clusters for Clean Hydrogen Utilization
- Mitigate Criteria Air Pollutants in Hydrogen-Based Power Generation
- Advanced Hydrogen Refueling Infrastructure Solutions for Heavy Transport

Energy Efficiency

- Analysis of Residential Hot Water Distribution Designs

Entrepreneur Development

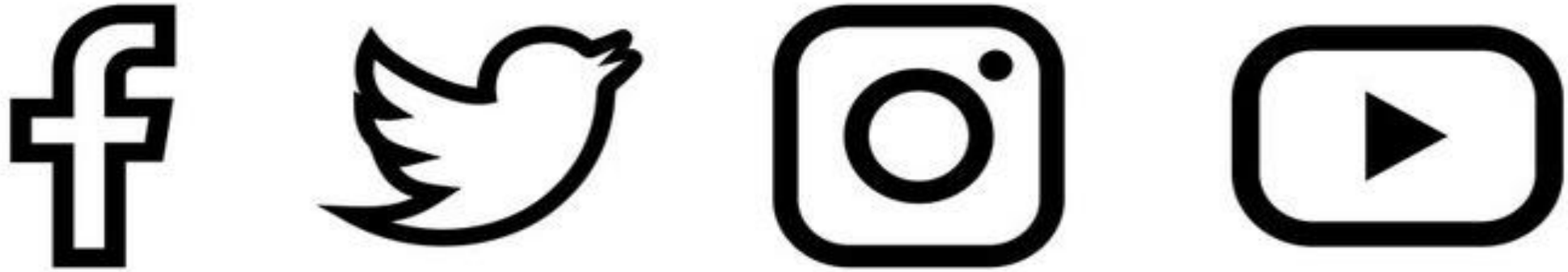
- California Sustainable Energy Entrepreneur Development (CalSEED) – Low Carbon Gas

Feedback

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

Comments can be provided to the PIER Gas Docket until ***January 31, 2022:*** https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=16-PIER-01

These comments will be considered while developing the *FY 2022-23 Gas R&D Proposed Budget Plan.*



Connect with Us

- The Energy Commission can be found on most social media platforms, Facebook, YouTube, Twitter, and LinkedIn.
- Energize Innovation provides access to the CEC R&D project resource libraries, tools, and databases.

Break

Stretch, grab a snack/beverage and see you in 5 minutes…

Session II

Contractor Presentation

Establishing a Long-Term Natural Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals

APPENDIX E:
List of 2021 Gas R&D Events

January 2021:

- Staff Workshop to Discuss Proposed Gas Research Initiatives for FY 2021-22
- Pre-Application Workshop – RFP-20-501 – Establishing a Long-Term Natural Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals

March 2021:

- Scoping Workshop – Upcoming Solicitation Regarding Pilot test and Demonstration of Hydrogen Blending into Existing California Natural Gas System

May 2021:

- IEPR Commissioner Workshop on Building Decarbonization – National, Regional, and California Activities
- IEPR Commissioner Workshop on Natural Gas Infrastructure
- Scoping Workshop – Forthcoming Solicitation Regarding Research to Improve Characterization of Methane Emissions from California's Residential Sector

June 2021:

- IEPR Commissioner Workshop on Building Decarbonization – Equipment, Technology, and Supply Chain

July 2021:

- IEPR Commissioner Workshop on Building Decarbonization – Consumers and Decarbonization, Financing Decarbonization, Decarbonization and Workforce
- Electric Program Investment Charge 2021-2025 Investment Plan Scoping – Hydrogen Technology where staff presented background on active and upcoming hydrogen research funded by the Gas R&D Program
- Electric Program Investment Charge 2021-2025 Investment Plan Scoping – Industrial Decarbonization
- Staff Workshop: Forthcoming Solicitation Regarding A Data-Driven Tool to Support Strategic and Equitable Natural Gas Decommissioning

August 2021:

- IEPR Commissioner Workshop on the Role of Energy Efficiency in Building Decarbonization

- IEPR Commissioner Workshop on Building Decarbonization: Embodied Carbon and Refrigerants
- IEPR Commissioner Workshop to Accelerate Industrial Decarbonization
- Pre-Application Workshop – GFO-21-501 – Hydrogen Fuel Cell Truck and Bus Technology Integration and Demonstration

September 2021:

- IEPR Commissioner Workshop on Building Decarbonization Quality Installation of Heating and Air Conditioning Equipment

October 2021:

- Pre-Application Workshop – GFO-21-503 – Examining the Effects of Hydrogen in End-Use Appliances for Large Commercial Buildings and Industrial Applications
- Webinar hosted by Move LA on Emerging Technology in Passenger Transit: Planes, Trains, Buses and Ships where staff presented an overview of active transportation projects and initiatives funded by the Gas R&D Program

November 2021:

- Pre-Application Workshop: GFO-21-504 – Development of a Data-Driven Tool to Support Strategic and Equitable Decommissioning of Gas Infrastructure
- Staff presentation of the highlighted projects for the industrial, agriculture, and water sectors at 2021 Emerging Technologies Summit

December 2021:

- Pre-Application Workshop: GFO-21-505 – Improve Characterization of Methane Emissions from California's Residential Sector
- 2021 Emerging Technologies Summit, panel on Technology Advancements to Enable Low-Carbon Food Processing where staff and grant recipients presented on technology advancements to reduce emissions in the food processing sector

APPENDIX F:
FY 2022-23 Gas R&D Plan Equity Framework Topic Definitions

The FY 2022-23 Gas R&D Plan includes the application of the DACAG Equity Framework. The five key equity principles have been adapted to apply to the Gas R&D Program and Electric Program Investment Charge (EPIC Program).

Health and Safety

CEC will direct investments to optimize the health and well-being of California's most vulnerable communities by advancing clean energy technologies that lead to health benefits and impacts, build resiliency, address climate change vulnerabilities, and reduce climate and air-quality-related healthcare costs. For example, advancements in building envelopes and low-carbon cooling technologies will reduce exposure to climate change impacts such as wildfire and extreme heat. Disadvantaged communities will benefit from reduced emissions from advancements in transportation electrification, as well as innovations in load flexibility that can reduce and eliminate the need to run fossil fuel-powered peaker plants.

Access and Education

Accessibility is the extent to which cleantech products and services are usable and available to people from the widest range of backgrounds and capabilities. The CEC strives to remove barriers to clean energy technology adoption, as identified in the SB 350 Barriers Report and by relevant stakeholders. This is accomplished through technology demonstration and deployment (TDD) in under resourced communities, addressing community priorities, supporting relationship-building and partnerships among diverse stakeholders, ensuring meaningful community engagement with community-based organizations as key project partners, and investing in diverse businesses. CEC will address access and education through projects and program administration by (1) enhancing inclusivity by focusing on targeted outreach, meaningful engagement, and knowledge dissemination; (2) ensuring that technologies are applicable to community interests and responsive to local needs; and (3) supporting the sharing of culturally relevant and sensitive project information and educational materials for participating communities. Tracking and evaluating progress of such efforts will ensure that these interventions are successful.

Financial Benefits

CEC investments will lead to technological advancements that lead to financial benefits and cost savings while considering affordability and rate impacts. For example, improved energy efficiency and load flexibility will result in electric bill savings;

advancements in energy resilience from energy storage technologies will help reduce financial impacts to businesses facing grid reliability issues; and manufacturing advancements will reduce the costs of clean energy technologies. In addition, CEC EPIC funding can expand community investment by attracting additional public and private funding and building capacity for future grant applications and clean energy project developments CEC recognizes that the value of money varies with income, and EPIC investments will prioritize financial benefits in under resourced communities to improve energy equity.

Economic Development

CEC investments will support economic development by:

- Funding cleantech start-up companies that are committed to diversity, equity, and inclusion.
- Investing in manufacturing, entrepreneurship, job creation, and training that support workforce development pathways to high-quality careers in California.
- Encouraging hiring for low-income, disadvantaged, and underrepresented populations (including women, re-entry, and so forth).
- Supporting small and diverse business development and contracting.

For example, through support of the Entrepreneurial Ecosystem, the CEC seeks to grow the entrepreneurial talent pool and provide critical support at all stages of the technology development pipeline. TDD projects and manufacturing initiatives support job growth, on-the job training, and workforce development, and include opportunities in regions facing high rates of unemployment and underemployment.

Consumer Protection

As a technology R&D program, the Gas Research & Development program does not directly address consumer protection in any initiative; thus, consumer protection was not included in the Equity Matrix (Table 3). Rather, through investments that work to advance clean energy technologies, the Gas R&D program is supporting consumer protection by demonstrating and de-risking the adoption of emerging clean energy technologies.

Direct and Indirect Benefits

Direct impacts are expected as a direct result of project implementation. For example, occupant health benefits from indoor air quality improvements from TD&D projects that includes electrification of gas appliances, and economic development from geothermal energy projects that hire local workers and support workforce development.

Indirect impacts are expected more broadly outside of project implementation. For example, indirect health benefits associated with technological advancements of an induction cooktop that will improve indoor air quality but did not include demonstration leading to direct benefits to an occupant, and increased economic development as a

result of geothermal energy advancements that may lead further adoption and job creation in geothermal energy.