CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

ENERGY RESEARCH AND DEVELOPMENT DIVISION

Staff Report

Gas Research and Development Program

Proposed Budget Plan for Fiscal Year 2024–25

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PREPARED BY:

Daphne Molin
Primary Authors

Neeva Benipal
Project Manager
California Energy Commission

Kevin Uy
Branch Manager
ENERGY SUPPLY BRANCH

Jonah Steinbuck, Ph.D.
Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Drew Bohan
Executive Director

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The following Energy Research and Development Division staff contributed to the development of the 2024–25 Gas Research and Development Budget Plan:

Angie Gould

Anthony Ng

Antonio Gomez

Cammy Peterson

Colleen Kredell

Jason Tancher

Jeffrey Sunquist

Kaycee Chang

Kevin Uy

Martine Schmidt-Poolman

Mithra Moezzi

Nadia Richards

Peter Chen

Rey Gonzalez

Rhetta DeMesa

Rizaldo Aldas

Susan Wilhelm

Yu Hou

PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission, and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to the marketplace. The EPIC Program is funded by California utility customers under the auspices of the California Public Utilities Commission. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the Energy Research and Development Division at ERDD@energy.ca.gov.

ABSTRACT

In 2000, Assembly Bill (AB) 1002 (Wright, Chapter 932, Statutes of 2000) was enacted, requiring the California Public Utilities Commission (CPUC) to add a surcharge on gas consumed in California. This surcharge funded various energy efficiency programs and public interest research and development to benefit gas ratepayers. AB 1002 also required the CPUC to designate an entity to administer the research component of AB 1002. In 2004, the CPUC issued Decision 04-08-010, designating the California Energy Commission (CEC) as the research fund administrator.

This Gas Research and Development Budget Plan describes the CEC's proposed gas research and development initiatives for Fiscal Year 2024–25. The proposed research and development aligns with the themes of gas decommissioning, gas system safety, renewable generation, and building decarbonization. The initiatives support state energy policies and goals, with several initiatives directly benefiting under-resourced communities. The proposed research funding for Fiscal Year 2024–25 is $24 million plus an additional $4,620,719 of supplemental funds. The budget plan covers July 1, 2024, through June 30, 2025. The budget plan benefited from input from representatives of the Disadvantaged Communities Advisory Group, CPUC and other agency coordination, and a public workshop, among other input received on CEC's gas-related efforts.

The CEC staff appreciates the coordination with CPUC on the proposed research initiatives and CPUC's ongoing support to enable access to needed utility infrastructure data.

Keywords: California Energy Commission, California Public Utilities Commission, gas, climate change, fuel-flexible generation, distributed generation, renewable generation, district heating, renewable gas, energy infrastructure, gas decommissioning, gas pipeline integrity, gas storage inspection and monitoring, geothermal, energy-related environmental research, transportation, building decarbonization, disadvantaged communities, low-income communities, decarbonization, hydrogen, ammonia, gas users, energy transition, indoor air quality, equipment supply chains

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The CEC's Energy Research and Development Division staff develops the Gas R&D Budget Plan based on state energy policies, plans, and guidance; analysis of research gaps; coordination with the California Public Utilities Commission (CPUC) and other agencies; and stakeholder input. Key policies, plans, and guidance include Executive Order B-55-18, Assembly Bill (AB) 1279 (Muratsuchi, Chapter 337, Statutes of 2022), Integrated Energy Policy Reports, and CPUC decisions and resolutions, among others.

This proposed Fiscal Year (FY) 2024–25 Gas R&D Budget Plan includes R&D funding for four initiatives aligned with four themes (Table ES-1). The proposed R&D serves to support gas decommissioning (retiring portions of California's fossil gas infrastructure to reduce costs of maintaining and operating the fossil gas system), gas system safety, renewable generation, and building decarbonization. Funding for these initiatives is requested from the FY 2024–2025 annual budget, as well as $4,620,719 in unspent funds from previous annual budgets.

The FY 2024–25 Gas R&D Budget Plan benefited from input from representatives of the Disadvantaged Communities Advisory Group, CPUC coordination, and a dedicated public workshop, among other input received on CEC's gas-related efforts.

Table ES-1: Proposed FY 2024–25 Gas R&D Budget Plan

Initiative Themes	Initiative Title	Proposed Budget	Proposed Supplemental Budget
Gas Decommissioning	Support Equitable, Safe, and Cost-Effective Decarbonization of California's Gas System	$7,000,000	
Gas System Safety	Innovations for Cost-Effective Operation and Maintenance of Critical Infrastructure During the Gas Transition	$5,000,000	$3,000,000
Renewable Generation	Fuel-Flexible Distributed Power Generation	$8,000,000	
Building Decarbonization	Networked Geothermal District Heating Study	$5,000,000	$1,620,719
Program Administration		$2,400,000	
TOTAL		$24,000,000	$4,620,719
Grand TOTAL		**$28,620,719**	

Source: California Energy Commission

CHAPTER 1: Introduction

Gas Sector Transition to Meet Decarbonization Goals

As California progresses toward its clean energy and climate change mitigation goals, the role of the gas sector and the mix of fuels — including fossil gas, biomethane, and clean hydrogen — will change. Key policies driving this transition include the Building Energy Efficiency Standards — Title 24 (Energy Code), Appliance Efficiency Regulations — Title 20, Senate Bill (SB) 350 (De León, Chapter 547, Statutes of 2015), and Senate Bill 100 (De León, Chapter 312, Statutes of 2018), among others. However, fossil gas use remains significant, and the overall gas demand in California could grow over the next decade in a business-as-usual scenario.[1]

The California Air Resources Board (CARB) published an update to its Scoping Plan for achieving carbon neutrality by 2045.[2] The Scoping Plan recognizes the need for decarbonization in every sector and replacing fossil fuels with renewable energy resources, including renewable and zero-carbon electricity, renewable hydrogen, and biomethane. While these replacements hold significant promise for driving emissions reductions, further technology development will help realize the full benefits of this market transformation, with improved technology performance and lower costs.

Gas R&D Program Background

The Gas Research and Development (Gas R&D) Program supports the gas sector transition and cost-effective achievement of the state's clean energy and climate goals. Research and development (R&D) investments lower the cost and improve the performance of low-carbon gas products, infrastructure, and services, supporting reductions in fossil gas consumption; advancing the production and use of renewable, low-carbon fuels; and delivering public health, environmental, and gas system safety benefits.

Recognizing the benefit of gas research to Californians, Assembly Bill (AB) 1002 (Wright, Chapter 932, Statutes of 2000) directed the California Public Utilities Commission (CPUC) to add a surcharge on gas consumed in California to fund R&D specific to the gas system. The 2004 CPUC Decision 04-08-010 designated the California Energy Commission (CEC) as the administrator for the Gas R&D Program. The CPUC allocates $24 million annually and defines public interest gas research activities as those "directed towards developing science or technology, and 1) the benefits of which accrue to California citizens, and 2) are not

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1 Javanbakht, Heidi, Cary Garcia, Ingrid Neumann, Anitha Rednam, Stephanie Bailey, and Quentin Gee. California Energy Commission. 2022. "*Final 2021 Integrated Energy Policy Report, Volume IV: California Energy Demand Forecast", Publication* Number: CEC-100- 2021-001-V4.

2 California Air Resources Board. 2022. "*2022 Scoping Plan for Achieving Carbon Neutrality."* https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/2022-scoping-plan-documents.

adequately addressed by competitive or regulated entities."[3] The decision also provides direction that R&D projects focus on energy efficiency, renewable technologies, conservation, and environmental issues; support state energy policy; offer a reasonable probability of providing benefits to the public; and consider opportunities for collaboration and cofunding with other entities, such as federal and local agencies.

In 2006, the California Legislature passed Sente Bill 1250 (Perata, Chapter 512, Statutes of 2006), which further outlines the goal of the Gas R&D Program to "develop, and help bring to market, energy technologies that provide increased environmental benefits, greater system reliability, and lower system costs, and that provide tangible benefits to electric utility customers." [4] In addition to these goals, the CPUC has issued resolutions providing further guidance for implementing the Gas R&D Program.[5]

In 2021, the California Legislature passed Assembly Bill 148 (Ting, Chapter 115, Statutes of 2021). This law authorizes continuous appropriation of funds in the CEC subaccount in the Public Interest Research, Development, and Demonstration Fund to the CEC for its costs of administering the Gas R&D program. While Gas R&D Program funds do not expire, the CEC strives to encumber these funds within two years and complete projects within a total of six years, when possible, which aligns with the original law. The CEC is also required to report to the Legislature on the outcomes, effects, and benefits of the program by October 31 of each year.

The Gas R&D Program has invested in R&D to develop technologies, tools, and strategies that increase energy efficiency, lower energy cost, reduce air pollutants and greenhouse gas (GHG) emissions, and improve the safety of gas infrastructure. Recent program achievements are included in the *Gas Research and Development 2023 Annual Report.*[6]

Fiscal Year 2024–2025 Budget Plan Priorities and Development

The proposed Fiscal Year (FY) 2024–25 Gas R&D Budget Plan continues to place emphasis on R&D areas that align with the state's priorities for decarbonization. The proposed R&D serves to support gas decommissioning, gas system safety, renewable generation, and building decarbonization. The CEC Energy Research and Development Division (ERDD) staff develops the Gas R&D Budget Plan based on state energy policies, plans, and guidance; analysis of

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3 California Public Utilities Commission. 2004. "*California Public Utilities Commission Decision 04-08-010*", https://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/39314.PDF.

4 California Code, 2006. "*Public Resources Code Sections 25620-25620.15"* codifies SB 1250, https://codes.findlaw.com/ca/public-resources-code/prc-sect-25620.html.

5 California Public Utility Commission. "*Energy Research Development and Deployment*," https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/energy-research-development-and-deployment.

6 O'Hagan, Molly. California Energy Commission. October 2023. "*Gas Research and Development Program 2023 Annual Report*." Publication Number: CEC-500-2023-054, https://www.energy.ca.gov/publications/2023/gas-research-and-development-program-2023-annual-report.

research gaps; coordination with the CPUC and other agencies; and stakeholder input, as discussed in Chapter 2.

CHAPTER 2:
Developing Gas R&D Initiatives for Fiscal Year 2024–2025

The research initiatives described in Chapter 3 of this report were informed by state policies, plans, and guidance — including in CPUC decisions discussed below — as well as the CEC's commitment to diversity and equity, stakeholder input, and state agency roadmaps, as discussed below and in Appendices A–F. A summary of CEC's process, including when stakeholders (ranging from the general public to technical experts) can provide input throughout the life cycle of Gas R&D Program activity, is included in Figure 1.

Figure 1: Summary of Key Input Activity for the Gas R&D Program Grant Solicitation and Agreement Management Process

Source: CEC Staff

CPUC Decision 04-08-10: Supporting State Policy

As called for in CPUC Decision 04-08-010, issued in 2004, the Gas R&D Program supports state energy policies and goals, such as achieving economywide carbon neutrality by 2045 (Executive Order B-55-18 and AB 1279, Muratsuchi, Chapter 337, Statutes of 2022) and doubling energy efficiency by 2030 (Senate Bill 350, De León, Chapter 547, Statutes of 2015).[7] [8]

The Gas R&D Program supports several other key energy and climate policies and goals, including:

- Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), which establishes the state's goal for a 40 percent GHG emissions reduction below 1990 levels by 2030.
- CEC Integrated Energy Policy Reports and associated updates (IEPRs), which assess major energy trends facing California's electricity, gas, and transportation fuel sectors and provide policy recommendations.[9]
- CARB's Climate Change Scoping Plan, which underscores the pivotal role of innovative technologies in improving efficiency, increasing the production of renewable gas, and reducing leakage from gas infrastructure in meeting future climate change targets.[10]

The FY 2024–25 Gas R&D Budget Plan also specifically addresses the focus areas identified in CPUC Decision 04-08-10, including the following:

- renewable technologies (with an initiative in the area of renewable distributed power generation),
- conservation and energy efficiency (with an initiative in building decarbonization), and
- environmental issues (including building decarbonization, gas system safety, and targeted gas system decommissioning).

Initiative themes of the budget plan also support sets of policies, as described in Appendix A.

CPUC Resolution G-3592

The CPUC Resolution G-3592, issued in 2023, required that the FY 2023–24 Gas R&D Budget Plan allocate $960,000 for CPUC to hire a contractor to evaluate the Gas R&D Program. The resolution also added seven new administrative requirements for the FY 2023–2024 Budget

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7 Executive Order B-55-18, *To Archive Carbon Neutrality*, 2018, https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf, & Assembly Bill 1279, Muratsuchi, *The California Climate Crisis Act, 2022*, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1279.

8 Senate Bill 350, De León. *Clean Energy and Pollution Reduction Act of 2015*, 2015, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.

9 Integrated Energy Policy Report. California Energy Commission. https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report.

10 California Air Resources Board. "*Assembly Bill 32 Climate Change Scoping Plan*," https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan.

Plan and beyond. The CEC addressed these requirements, which are summarized below, in the chapters or appendices as noted in parentheses:

1. Engage with and include input from disadvantaged community stakeholders, including the DACAG, to provide input on how to administer the program equitably (Chapters 2 and 3).
2. Offer a presentation of the budget plans to the CPUC commissioners (offer to present the proposed budget plan was sent January 25, 2024).
3. Describe collaborative and cofunding opportunities considered (Chapters 2 and 3).
4. Summarize investor-owned utility (IOU) coordination on the Gas R&D Budget Plan, and provide details on partnerships, costs, and cofunding for projects funded by the Gas R&D Program (Chapters 2 and 3).
5. Provide a detailed cost breakdown of Gas R&D Program administration (Appendix G).
6. Summarize how the Long-Term Research Roadmap was considered in developing the budget plan (Chapters 2 and 3).
7. Identify unspent funds that had been proposed in previous budget plans and use them before using new or additional ratepayer funds (Appendix B).

CPUC Resolution G-3592 will require the CEC to apply the Electric Program Investment Charge (EPIC) impact analysis framework, once established, to Gas R&D projects and initiatives. The framework is not yet established for CEC to use.

CPUC Resolution G-3584

As directed by CPUC Resolution G-3584, issued in 2021, the CEC considered the Assembly Bill 3232 (Friedman, Chapter 373, Statutes of 2018) report in developing the FY 2022–23 Gas R&D Budget Plan, specifically the seven key strategies to decarbonize residential and commercial buildings outlined in the 2021 report *California Building Decarbonization Assessment.*[11] Some of the initiatives in the FY 2024–25 Gas R&D Budget Plan support the recommended strategies.

The "Fuel-Flexible Distributed Power Generation" research initiative supports the second strategy detailed in the report for "Decarbonizing the Electricity Generation System." The initiative proposes using different types and qualities of renewable fuels, such as hydrogen, biomethane, or ammonia, in distributed generation technologies to enable them to be fuel-flexible. [12] The initiative will take a technology-neutral approach that encompasses a range of strategies, from cutting emissions from combustion systems to expanding the operability of non-combustion systems. This approach seeks to modify or develop prime movers to operate on one or more renewable fuels, thereby expanding the suite of strategies to achieve a cleaner generation system.

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

12 *Distributed Generation* means producing electricity near the place of use.

The report also includes a strategy for "Decarbonizing the Gas System." While CEC originally considered a Clean Renewable Hydrogen Distribution research initiative to study the role of hydrogen separation technologies in understanding whether and how hydrogen should be used to displace fossil gas in the existing gas system, CEC ultimately decided not to include this initiative in the FY 2024–2025 Proposed Budget Plan. This decision was based largely on CPUC and stakeholder feedback, as summarized in Appendix C.

CPUC Resolution G-3584 calls for the CEC to consider, when available, the long-term research roadmap for gas technology development, titled *Recommendations for the Long-Term Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals*. The final analysis was submitted to the CEC on November 30, 2022, and a public workshop presenting the findings was held December 12, 2022. The analysis includes recommendations, which are organized around 11 initiatives: three under communities, equity, and environment; four under gas end use; and four under gas supply chain elements (production, transport, and storage). These recommendations now help guide Gas R&D investments and have partially informed the investments identified in this budget plan, as described in Chapter 3.

The Resolution G-3584 also requires the CEC to review the unspent funds in the Public Interest Energy Research Development and Demonstration Fund CEC subaccount to identify research funds from FY 2014–2015 to FY 2022–2023 Gas R&D Budget Plans that were encumbered within two years of budget approval (Appendix B). Per the 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.

CPUC Resolution G-3571

CPUC Resolution G-3571, issued in 2020, requires that if the CEC is unable to obtain data it deems necessary to complete any of the projects proposed in the FY 2021–2022 Gas R&D Budget Plan, it must first consult with CPUC Energy Division staff overseeing this program before reallocating any funding. The CEC or its project recipients have not yet required data to complete the projects in the FY 2021–2022 Gas R&D Budget Plan or projects proposed in any subsequent Gas R&D Budget Plan. However, the CPUC and CEC have an information-sharing agreement to support the Gas R&D Program and ensure that the confidentiality of exchanged information will be maintained.[13] Should the CEC be unable to obtain needed data, the CEC staff will consult with CPUC Energy Division staff before reallocating any funding as required in the CPUC's resolution.

The resolution also calls for the CEC to consider "any research gaps that might emerge because of recent budget decreases or reallocations in response to COVID-related economic impacts and potential cofunding opportunities that the Gas R&D program can provide to limit the impact of these gaps on California energy goals." However, at this time, the CEC is not aware of budget decreases or reallocations that may result in research gaps.

13 Available upon request.

For all Gas R&D Budget Plans, CPUC asked that the CEC coordinate with CPUC staff at least three weeks in advance of the CEC's public workshop on the proposed budget plan. This additional step helps ensure the best possible use of funds across programs. In response, the CEC staff provided CPUC staff with summaries of the research initiatives November 2, 2023, and organized a staff coordination meeting for November 15, 2023. A summary of this meeting is provided in Appendix C.

The CPUC also included a requirement that, for all Gas R&D Budget Plans, the CEC post the budget plans publicly on the CEC's website before submitting an approval request to the CPUC and notify the CPUC of the web address when requesting approval of the plan. The CEC follows this practice, with Gas R&D Budget Plans posted to the CEC's website, on the page for Energy Research and Development investment plans and annual reports.[14]

For all Gas R&D Budget Plans, the CPUC called for the CEC to distribute the budget plan through the CEC's subscription lists and include the names of the lists served when requesting CPUC's approval of the plan. The resolution also calls for the CEC to consult with Energy Division staff on which CPUC list serves from ongoing CPUC proceedings the CEC should notice in its proposed plan. Addressing that request, the CEC notes that the noticed CEC lists will include "Energy Research and Development"; "PIER Pgm. Residential and Commercial Bldgs. Program Area"; "Developing Regulations, Guidelines, and Policies for Implementing SB 350 and AB 802"; "Renewable Energy Executive Order", and "General Natural Gas and LNG Issues."[15]

Moreover, the resolution asks that, for all Gas R&D Budget Plans, the CEC consult with CPUC to allow the option of presenting the budget plan to the CPUC commissioners during a CPUC commissioner committee meeting. This request was revised via CPUC Resolution G-3592, and the CEC responded accordingly.

Equitable Program Administration

The CEC's commitment to diversity and equity shaped the Gas R&D Program. California is a diverse state in its people and geography. The CEC strives to increase opportunities for all Californians through its programs and advances equity through outreach, funding opportunities, and planning. In 2015, the CEC unanimously approved a formal Diversity Policy Resolution, consistent with state and federal law. The resolution seeks to improve fair and equal opportunities for small businesses; women-, disabled veteran-, minority-, and lesbian, gay, bisexual, transgender, and queer (LGBTQ)-owned businesses; and economically

14 California Energy Commission. "*Annual Report*," https://www.energy.ca.gov/data-reports/reports/energy-research-and-development-investment-plans-and-annual-reports.

15 California Public Utilities Comission. Listservs include A1704028, A1806015, A1902015, A1907006, A1910012, A1908015, A2106021, A1710008, A1807024, I1911013, R1602007, R1803011, R1804019, R1807006, R1810007, R1812005, R1812006, R1901011, R1211005, R1910005, R1302008, R2001007, R1407002, R2005012, R1503010, R.1901011, R2008020, R1505006, R2011003.

disadvantaged and underserved communities to participate in and benefit from CEC programs.[16]

Assembly Bill 865 (Alejo, Chapter 583, Statutes of 2015) provided additional guidance, requiring the CEC to develop and implement a comprehensive outreach plan to broaden and diversify the applicant pool to CEC programs and track progress toward those objectives. The *2022 IEPR Update* includes a draft revision to the Justice Access Equity Diversity Inclusion (JAEDI) Framework, which reasserts the CEC's commitment to equity by outlining its vision, values, and best practices to advance equity in its programs. The ERRD equity leads work with the CEC Public Advisor's Office to align the Gas R&D Program and other grant funding efforts with the JAEDI Framework.[17]

Some recent examples of outreach efforts to support diversity and equity commitments include improving the CEC's application and grant management processes to relieve administrative burdens for applicants. This improvement is particularly beneficial for new and underresourced entities, and tribes. In collaboration with the CEC grants ombudsman, R&D staff obtains feedback from applicants and works to implement improvements to the grant application process.

Examples of ongoing efforts to support diversity and equity include:

- Leveraging scoring criteria in solicitations to provide preference points for projects that demonstrate benefits to disadvantaged or low-income communities (or both), and tribes. The criterion considers factors such as economic impacts as well as improving access to clean energy within the community. Applications with letters of support demonstrating benefits to these communities and tribes are also considered.
- Continuing to advance efforts to address energy-related challenges and opportunities in under-resourced communities and tribes by encouraging residents and interested members to participate in and share perspectives in community meetings on CEC-funded projects.
- Continuing to track, monitor, and provide findings in the Gas R&D Annual Report on the participation of California-based entities; women-, minority-, and disabled-veteran-owned businesses; and small businesses as recipients of R&D awards. Since FY 2016–2017, the Gas R&D Program has invested about 72 percent of research funds in demonstration projects in either a disadvantaged community, low-income community, or both, with the aim to bring benefits to those communities. Recent program investments in disadvantaged

16 Resolution No: 15-0408-3, State Energy Resources Conservation and Development Commission. 2015. "*Resolution 15-0408-3: Resolution Regarding Diversity Policy Statement,"* https://www.energy.ca.gov/media/4163.

17 Bailey, Stephanie, Jane Berner, David Erne, Noemí Gallardo, Quentin Gee, Akruti Gupta, Heidi Javanbakht, Hilary Poore, John Reid, and Kristen Widdifield. 2023. "*Final 2022 Integrated Energy Policy Report Update*." California Energy Commission. Publication Number: CEC-100-2022-001-CMD, https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2022-integrated-energy-policy-report-update.

and low-income communities are included in the *Gas Research and Development 2023 Annual Report*.[18]

The CEC's Empower Innovation platform (EmpowerInnovation.net) provides an online space for community leaders and clean energy technology innovators to meet and learn from each other and start conversations that lead to effective collaboration. Staff has held "Empower Innovation" events focused on providing how-to technical assistance and navigating grant requirements. Recordings of these events are available to view for free on the platform. Furthermore, staff continues to share information on how to use the Empower Innovation platform at preapplication workshops for Gas R&D Program funding opportunities. These activities serve to help engage a broad set of stakeholders in the Gas R&D Program, including women, minorities, LGBTQ individuals, disabled veterans, and other underrepresented groups.

More information about these and other CEC activities that support equity and diversity is available on the CEC's website (https://www.energy.ca.gov/about/campaigns/equity-and-diversity).

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) is a driving policy for advancing equity in California's clean energy transformation. As outlined in SB 350, the CEC co-established the DACAG with the CPUC in 2018 to advise the CEC and the CPUC on ways to help disadvantaged communities benefit from proposed clean energy and pollution reduction programs, expand access to clean energy technologies, and receive affordable energy services.[19] CEC DACAG liaisons coordinate with the CEC Public Advisor's Office and DACAG members to discuss these topics and matters concerning energy equity and ensure that program implementation helps meet community needs.

In addition, CEC DACAG liaisons support technical staff in informing funding and focal areas and identifying outreach opportunities with the DACAG. These activities include providing staff updates and presentations on upcoming budget plans, programs, workshops, outreach events, and final reports related to the groups' priority areas in the DACAG monthly newsletter, public meetings, and smaller meetings with DACAG priority area subject matter experts.

CEC staff activities specifically related to CEC's commitment to diversity and equity for the FY 2024–2025 Gas R&D Proposed Budget Plan include:

- Consulting with CEC's Public Advisor's Office and DACAG members to identify relevant underresourced community and tribal stakeholders and effective engagement approaches to seek input on how to administer the program equitably throughout the plan development and implementation cycles.

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18 O'Hagan, Molly. October 2023. "*Gas Research and Development Program 2023 Annual Report*." California Energy Commission. Publication Number: CEC-500-2023-054, https://www.energy.ca.gov/publications/2023/gas-research-and-development-program-2023-annual-report.

19 Scavo, Jordan, Suzanne Korosec, Esteban Guerrero, Bill Pennington, and Pamela Doughman. 2016. *"Low-Income Barriers Study, Part A: Overcoming Barriers to Energy Efficiency and Renewables for Low-Income Customers and Small Business Contracting Opportunities in Disadvantaged Communities."* California Energy Commission. Publication Number: CEC-300-2016-009-CMF.

- Providing targeted outreach to the DACAG, California Environmental Justice Alliance, Asian Pacific Environmental Network, and the California Energy Research Center (focused on expanding education, training, and demonstration projects in the Central Valley) about the December 15, 2023, Gas R&D Plan Stakeholders Workshop and offering the opportunity for public comment.
- Issuing a request for comments to elicit public input on how to center equity in the proposed initiatives in the 2024–2025 Gas R&D Program.
- Presenting and soliciting feedback on the proposed initiatives of the Gas R&D Program and the proposed equity engagement approach at the DACAG meeting on January 19, 2024. Staff incorporated changes to the Gas R&D Plan based on DACAG input.
- Periodically meeting with DACAG members to receive recommendations on how to effectively address equity and improve benefits to under-resourced communities and tribes through proposed R&D initiatives.

Looking ahead, CEC staff members are planning a listening session for later in 2024 to invite input by environmental justice and community-based organizations to guide future budget plan initiatives. Furthermore, per DACAG request at the January 19, 2024, public meeting, staff is coordinating with the CEC Public Advisor's Office to develop an approach for providing the DACAG with regular updates on ongoing research results and with opportunities to provide feedback on developing future funding efforts.

Stakeholder Coordination and Strategic Partnerships

The CEC staff engages with stakeholders to develop a research portfolio responding to various challenges in the gas sector. CEC staff initiates discussions with a wide range of experts to understand current challenges, emerging needs, and technology advancements within the gas system. This early scoping assists with creating well-informed research initiatives and establishing clear research priorities.

After proposed research initiatives are approved by the CPUC, CEC staff conducts in-depth research to focus the future funding areas and develop solicitation requirements. Throughout this process, CEC staff may inquire with various experts and other stakeholders, such as those listed below, to explore emerging efforts that may potentially shape future solicitations. However, once solicitations have entered the development phase, the CEC does not collaborate in crafting grant solicitations to ensure compliance with Public Resources Code Section 25620.5(a), which requires these grant solicitations to be competitively selected and awarded. [20] To ensure a fair and open selection process, the CEC does not share draft solicitation materials with prospective grant applicants or their project partners, which may include IOUs. These measures ensure fairness, transparency, and integrity throughout the solicitation process.

20 Per the Public Utilities Code Section 895(a), the CEC administers the Gas R&D Program under Public Resources Code Sections 25620–25620.15 and evaluates and selects of projects based on merit through a competitive process.

Examples of broad, annual coordination include:

- Southern California Gas Company (SoCalGas) Research, Development and Demonstration Department on its annual research plans. This example includes CEC staff participation in outreach meetings to guide SoCalGas' research priorities, attending SoCalGas' annual public workshop on its RD&D plan, and meetings between CEC and SoCalGas subject matter experts on specific research priorities such as hydrogen and transportation.
- Pacific Gas and Electric (PG&E) on its gas operations and hydrogen-related R&D priorities through meetings between CEC and PG&E subject matter experts and CEC attendance at PG&E's R&D outreach events, such as its Innovation Summit and Pitch Fest.
- The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration and Pipeline Research Council International on gas infrastructure safety and integrity research.
- The U.S. Department of Energy Advanced Research Projects Agency—Energy on the Rapid Encapsulation of Pipelines Avoiding Intensive Replacement Program.

CEC staff also participates in regular meetings internally with state and federal agency partners. Examples of related topics discussed include:

- Application-driven climate science (led by the National Oceanic Atmospheric Administration).
- Forest biomass (led by the California Department of Forestry and Fire Protection).
- Climate data and analyses to support a resilient energy transition (led by CEC).
- Health, energy, and equity (led by CEC).
- Hydrogen hub efforts, including end-use and infrastructure issues (led by Alliance for Renewable Clean Hydrogen Energy Systems [ARCHES], which includes the California Governor's Office of Business and Economic Development [GO-Biz]).

The CEC also conducted a public workshop December 15, 2023, to present the Proposed FY 2024–2025 Gas R&D Budget Plan. About 60 people attended the workshop, not including CEC staff, and the CEC received a half-dozen attendee questions and comments during the workshop discussion. The CEC considered and responded to stakeholder comments associated with budget plan development. For instance, after considering this feedback, that from the January DACAG meeting, and current funding and stakeholder priorities, the CEC decided not to pursue the clean renewable hydrogen distribution initiative theme this year. (See Appendices C and D for the staff workshop presentation and a summary of public comments and CEC staff responses, respectively.)

The CEC also engages a diverse set of stakeholders in R&D implementation. This outreach promotes program accountability, transparency, collaboration, and responsiveness. The CEC relies on these strategic partnerships to avoid duplication, build upon previous R&D work, generate new ideas, leverage public and private investments, and ultimately ensure the

research portfolio delivers tangible benefits to the state's gas ratepayers. This engagement includes broadening the use of social media platforms to educate and inform; collaborating with the CEC's Public Advisor to promote grant-funding opportunities; meeting with community leaders, business leaders, and other stakeholders; and distributing R&D informational materials at conferences, meetings, workshops, and public events, including nine events in 2023. (A list of public events is provided in Appendix E.)

Collaborative and Cofunding Opportunities

The CEC engages with a wide range of California stakeholders — including research institutions, governmental agencies, industry, utilities (for example, PG&E and SoCalGas), and the public — to incorporate diverse perspectives on gas public interest energy research projects (Public Resources Code Section 25620.1[c][10]). The CEC has an ongoing collaboration with PG&E, San Diego Gas & Electric (SDG&E), and SoCalGas that includes their participation as members of technical advisory committees or project teams, and as demonstration site hosts. Moreover, CEC staff has regular coordination meetings with CPUC staff to support the execution of ongoing projects and share perspectives on emerging issues related to policy, reliable gas system operations, and cost.

The CEC leverages cofunding opportunities by either requiring applicants for competitive solicitations to secure match funding (usually 10–20 percent), providing additional scoring preferences for applications that exceed the minimum match funding requirement, or both. The cumulative match investments and project successes of the program are summarized in the Gas R&D Program Annual Report. As an example, the FY 2021–2022 Budget Plan resulted in competitively awarded projects bringing in nearly $8 million in match funds, effectively increasing the program funding level by 30 percent. A total of $1.5 million of these match funds came from IOUs (such as SoCalGas), $1.23 million from community- or publicly funded entities (for example, the South Coast Air Quality Management District), and $5.1 million from private entities.

Roadmaps and Long-Term Strategies

Roadmaps and long-term strategies are types of planning mechanisms and prioritization tools that help establish a clear link between research and energy policy goals. Research roadmaps define the topic area, significant issues and barriers, data gaps, information needs, research priorities, and potential partnerships. CEC staff and a wide range of energy researchers and consumers participate in developing roadmaps and strategies to gather cutting-edge information that can help determine how to maximize the value of Gas R&D Program investments.[21]

Public feedback during development of these roadmaps helps identify research needs that pertain to the Gas R&D Program. Collaborative thinking about energy solutions that cut across policy boundaries is integral to leveraging research dollars. Bringing gas and electricity

21 Various roadmaps can be found at the Energy Commission's publications database, https://www.energy.ca.gov/energy-rd-reports-n-publications.

stakeholders together to develop roadmaps minimizes resource shifting, encourages innovation, and promotes transparency.

The Gas Decommissioning initiative, for example, drew from IEPRs and the CEC's Gas Decarbonization Order to Institute Informational Proceeding (Gas Decarb OIIP). [22] [23] Both IEPRs and the Gas Decarb OIIP highlight the need for long-term gas system planning, pointing to many unknowns and evolving energy sector needs related to building decarbonization and gas decommissioning targets. These various planning needs include:

- Coordinating gas system decommissioning with building decarbonization and changing weather patterns,
- Understanding and accounting for gas-electricity system interdependencies,
- Ensuring safe, reliable, and affordable energy for Californians,
- Maintaining an adequate gas industry workforce, exploring lower-carbon gas options, and
- Mitigating risks to communities, including disadvantaged and lower-income communities.

Similarly, the Fuel-Flexible Distributed Power Generation initiative drew from recommendations in the *2022 IEPR Update* and the *Draft 2023 IEPR* to support the research and development on clean renewable hydrogen generation to improve efficiency, address oxides of nitrogen (NO_x) formation, and understand materials impacts, especially at higher blends. [24][25] This initiative was also motivated by the California Air Resources Board's 2022 Scoping Plan and SB 100 emphasis on the need for adaptable generation systems to decarbonize and eliminate use of fossil fuels.

For example, the anticipated fuel changes ordered under Senate Bill 1440 (Hueso, Chapter 739, Statutes of 2018) could lead to a significant increase in biomethane going into the gas pipeline system. With substantial federal investments, particularly from the Infrastructure Investment and Jobs Act for the ARCHES effort and the Inflation Reduction Act for the Clean Hydrogen Production Tax Credit, increased production and use of hydrogen could also occur, as the price of clean renewable hydrogen decreases. With these potential changes, the renewable fuel stream of the future might vary in quality, composition, and characteristics to

22 See, for the *2021 IEPR* for example, Jones, Melissa, Jennifer Campagna, Catherine Elder, and Stephanie Bailey. 2022. *Final 2021 Integrated Energy Policy Report, Volume III: Decarbonizing the State's Gas System*. California Energy Commission. Publication Number: CEC-100-2021-001-V3, especially pp. 88-90, https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report.

23 State of California Order No. 22-0309-07,https://efiling.energy.ca.gov/GetDocument.aspx?tn=242287&DocumentContentId=75788.

24 Bailey, Stephanie, Jane Berner, David Erne, Noemí Gallardo, Quentin Gee, Akruti Gupta, Heidi Javanbakht, Hilary Poore, John Reid, and Kristen Widdifield. 2023. *Final 2022 Integrated Energy Policy Report*. California Energy Commission. Publication Number: CEC-100-2022- 001-CMF.

25 Bailey, Stephanie, Jennifer Campagna, Mathew Cooper, Quentin Gee, Heidi Javanbakht, and Ben Wender. 2023. *Draft 2023 Integrated Energy Policy Report.* California Energy Commission. Publication Number: CEC-100-2023-001-CMD

an extent that current generation systems are not capable of handling. Research will be valuable to evolve and adapt these systems.

Beginning in 2021, the CEC managed a contract that developed an analysis to support a long-term gas research strategy aligned with California's aggressive carbon neutrality goals. The contactors used a combination of literature review, technology assessments, prioritization methodologies, and stakeholder input to produce recommendations for the Gas R&D Program. Stakeholder input included TAC meetings, several public workshops, and expert stakeholder interviews.[26] The analysis informs opportunities for gas-related research and development investment across the gas supply chain and all end-use sectors except utility-scale power generation, spanning opportunities in hydrogen, renewable gas, gas decommissioning, gas safety, carbon capture utilization and storage, and health and equity. The CEC considered this analysis in developing this budget plan.

26 https://www.energy.ca.gov/event/webinar/2022-12/webinar-long-term-gas-research-strategy-recommendations

CHAPTER 3:
Proposed Initiatives for Fiscal Year 2024–2025

Proposed Budget Overview

This proposed FY 2024–2025 Gas R&D Budget Plan includes funding for four initiatives aligned with four program themes (Table 1). The proposed R&D serves to address the following topics:

- Gas decommissioning
- Gas system safety
- Renewable generation
- Building decarbonization

Table 1 includes a proposed supplemental budget of $4,620,719 that consists of funds from renewable generation and cross-cutting research initiatives under past budget plans, such as from cancelled grants and unspent or unencumbered funds.[27] Assembly Bill 148 (Committee on Budget, Chapter 115, Statutes of 2021) provided the CEC with authority to continuously appropriate gas funds from the Public Interest Energy Research, Development, and Demonstration Fund for administering energy-related programs.[28] As a result, Gas R&D funds do not have encumbrance or liquidation dates, since they are continuously appropriated.

However, the CEC endeavors to encumber the funds within two years and have the projects completed and funds liquidated in six years. In this and future plans, the CEC will continue to propose a supplemental budget to reuse any unspent, unencumbered, or other available funds in the Public Interest Energy Research, Development, and Demonstration Fund CEC subaccount.

27 FY 2022-23 $921,404 unspent funds in Decarbonization of Gas End Uses and Gas Pipeline Safety and Integrity, FY 2017-18 $865,642 unspent funds in Transportation and FY 2016-17 $543,673 unspent funds in Energy Efficiency.

28 Assembly Bill 148. 2023. https://legiscan.com/CA/text/AB148/id/2676649.

Table 1: Proposed FY 2024–2025 Gas R&D Budget Plan

Initiative Themes	Initiative Title	Proposed Budget	Proposed Supplemental Budget
Gas Decommissioning	Support Equitable, Safe, and Cost-Effective Decarbonization of California's Gas System	$7,000,000	
Gas System Safety	Innovations for Cost-Effective Operation and Maintenance of Critical Infrastructure During the Gas Transition	$5,000,000	$3,000,000
Renewable Generation	Fuel-Flexible Distributed Power Generation	$8,000,000	
Building Decarbonization	Networked Geothermal District Heating Study	$5,000,000	$1,620,719
Program Administration		$2,400,000	
TOTAL		$24,000,000	$4,620,719
GRAND TOTAL		**$28,620,719**	

Source: California Energy Commission

Proposed Research Initiatives

Initiative Theme: Gas Decommissioning

The tasks of decarbonizing and decommissioning California's gas system confront decades of inertia favoring fossil gas use, complex costs and benefits of conversion, and community and organizational priorities that can misalign with conversion from fossil gas. Overcoming this inertia requires influencing long-evolved societal systems, including going beyond just intervening in decisions, such as what a homeowner chooses when replacing equipment. These societal systems manifest in varied conditions across California's diverse gas customer

base, retailers, and contractors and are not easily visible or manageable. Thus, beyond technological innovation, accomplishing gas decommissioning and decarbonization requires a research-based understanding of how ground-level changes in tens of millions of gas end uses can be achieved, and how these changes can be coordinated with infrastructural changes while meeting safety, resiliency, and energy equity goals.

This initiative supports nimble, rapid research that draws from existing data and fieldwork on ongoing experience and conditions. It is designed to produce insights that help achieve the massive reductions in fossil gas use envisioned in state goals, understand the varied consequences of these efforts, and provide timely, actionable results informing gas decarbonization policy, implementation, planning, and research. It will aim to improve the connection between high-level gas transition planning and pursuit of end-use changes.

Better understanding this bidirectional connection will inform actions and expectations for relevant processes, including:

- Influencing value chains to better favor alternatives to fossil gas end use.
- Anticipating changes in demand patterns and bringing these changes to bear in resource and reliability planning.
- Understanding and managing the impacts of this suite of changes.
- Building a deeper understanding of options for handling hard-to-electrify gas end uses.

In taking a distributional perspective rather than one more oriented to averages, research funded under this initiative will also highlight important elements of variability in transition opportunities and transition effects.[29] Making this variability more visible can foster greater energy equity and build a more systematic ground-level view of the technology needs, opportunities, and challenges in decarbonizing the gas system.

Initiative Title: Support Equitable, Safe, and Cost-Effective Decarbonization of California's Gas System

Initiative Description

This initiative covers all sectors, including the power sector, and incorporates three particular innovations. First, it focuses on drawing from existing data — including interval meter data on energy use — and from fieldwork that illuminates existing experiences, such as the decision processes of vendors and equipment purchasers when replacing gas-powered equipment, experiences with local gas bans, and lessons learned during the implementation of electrification programs. [30] In this manner, the initiative seeks to complement and leverage

29 This perspective is aligned with that outlined in Jasanoff, Sheila 2018. "Just Transitions: A Humble Approach to Global Energy Futures." *Energy Research & Social Science* 35: 11–14. https://doi.org/10.1016/j.erss.2017.11.025.

30 *Interval meter data* (sometimes abbreviated IMD) means energy demand data collected and transmitted by an interval meter, sometimes called "smart meters." For more information, see https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/the-benefits-of-smart-meters.

data, research results, and past and emerging experiences pertinent to transitioning from fossil gas.

Second, the initiative recognizes that the empirical grounding that this approach provides must be analyzed and presented in a way that guides ongoing planning, research, investment decisions, and state agency processes (for example, proceedings, rulemakings, and guidance) more quickly and purposively than the normal multiyear research cycle might naturally do. Research under this initiative will thus be crafted to accelerate the pace of information transference and associated near-term usability while maintaining quality and responding to mid- and longer-term perspectives. For example, grant agreements will be written to prioritize sharing interim results and permit sufficient flexibility to keep analysis on point as California's energy transitions evolve; processes to avoid acquisition delays for use of key data will also be developed.

Third, the projects under this initiative will aim to highlight options for understanding and influencing the micro conditions behind societal gas use and alternatives. These include:

- Identifying challenges and solutions in the gas transition value chain (for example, related to workforce development, technology, decisions, and policy instruments (such as subsidies and tariffs)
- Developing strategies that serve diverse needs and contexts across the state (for example, related to workforce development, materials availability, and site-specific energy resilience, the recognition of which can lead to innovations in local supply chains and improved strategies for energy resilience)
- Empirically tracking air quality impacts, health implications, and other costs and benefits from converting from fossil gas
- Coordinating the gas transition with overall energy resilience, including reinforcing weak electricity infrastructure where gas is a crucial source of energy and providing targeted improvement of emergency energy resources.

Expected Initiative Outcomes

Successful research under this initiative will increase the effectiveness of California's transition from fossil gas use. Success includes developing empirically grounded research approaches that increase the feasibility of gas sector decarbonization, disseminating information to policymakers, researchers, and other stakeholders on the distribution of costs and benefits including identifying niches where costs are particularly high, and providing analysis to assist in decommissioning planning and coordinating across disparate R&D topics to offer a more comprehensive long-term view.

These results can be used by stakeholders involved in California's gas system transition, including implementers focusing on achieving end-use conversion from fossil gas, planners who require better knowledge of expected patterns of gas use change (such as for demand forecasting or assessing safety), regulators and policy makers aiming to foster positive outcomes for California residents, and technology developers looking for opportunities to support the transition. The initiative complements efforts that focus more exclusively on trying

to convince end users to convert from fossil gas use by providing information or incentives. It instead draws attention to identifying and targeting systematic issues that impede conversion from fossil gas or retirement of gas infrastructure. It will also help refine transition planning by providing a clearer view of ongoing experiences and related implications, as well as guide technology development by outlining existing technical inadequacies that targeted innovation could help overcome. In addition, funded research will evaluate outcomes and characterize costs and benefits distributionally, supporting R&D, deployment, and policy approaches that help meet energy equity goals and help assure that anticipated benefits are delivered.

Benefits to Californians

Californians benefit from research supported by this initiative because of the focus on providing a strong empirical understanding of effective pathways for achieving end-use changes. This in turn supports assessing costs, benefits, and risks distributionally—that is, for different groups of consumers or other stakeholders. They also benefit from the strategy of leveraging existing data sources and experiences. This approach improves research cost-effectiveness and helps assure that results reflect real-world contexts. Results will guide CEC's Gas Decarbonization OIIP on Decarbonizing the Gas System (Order 22-0309-7) and CPUC's Long-Term Gas Planning Rulemaking (R. 20-01-007), benefiting all ratepayers.

- **Adaptation:** Results will highlight potential difficulties related to energy resilience, costs, or transition effectiveness that the state, industry, and other social groups (such as nongovernmental organizations and communities) can address.
- **Affordability:** Supported research will streamline decommissioning planning by systematically analyzing empirical data related to costs, thus reducing risk of costly missteps.
- **Safety and reliability:** Supported research will guide high-level gas transition planning, including the California Energy Demand Forecast, along with the reliability and resilience planning it shapes, and tactical elements of system decommissioning based on changing patterns of gas end use and related effects on hydraulics and derating decisions.
- **Equity:** By including a focus on patterns of gas use conversions and on variability of related costs, benefits, and risks across populations, research supported by this initiative can identify potential inequitable outcomes (e.g. consumers who rent homes may bear the costs of decommissioning without being able to themselves transition from gas, or reducing energy resilience in rural areas) in current and prospective decommissioning practices so they can be better addressed.
- **Environmental sustainability:** Research will help accelerate conversions of fossil gas end uses to lower carbon alternatives, reducing greenhouse gas emissions and other air pollution with accompanying benefits to environmental and human health.

Rationale

Because this research is not closely related to profits or to securing market position for specific technologies or economic activities, it is unlikely to be adequately addressed by competitive

markets. The initiative responds to key needs identified in state processes and studies, including (1) IEPRs and CEC's OIIP on Decarbonizing the Gas System, which highlight the need for long-term gas planning and risks of unduly burdening disadvantaged and lower-income communities; (2) conversations with CPUC gas policy branch staff during CEC-CPUC research meetings held in 2022–2024, CPUC's Long-Term Gas Planning Rulemaking documents, and feedback during the research plan development process; (3) SB 350 DACAG comments submitted to the CEC; (4) the Guidehouse analysis *Recommendations for the Long-Term Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals*, especially recommendations related to communities, equity, and environment.

Technology and Market Background

The gas energy transition market is at an early stage. There is limited experience from which to chart a path toward achieving policy aspirations. Most members of the public are only marginally aware of California's gas transition plans. Only small decommissioning pilots have been completed, and practical concepts related to executing decommissioning are still in development. Crucial uncertainties remain regarding the roles of low-carbon gases and non-pipeline alternatives, and major challenges lie in coordinating gas decommissioning with the reinforcements that are needed in the electricity system to accommodate increased electricity demand with sufficient reliability and resilience.

Projects funded by earlier Gas R&D decommissioning initiatives are continuing to make progress in compiling infrastructure and other geospatial data in guiding planning, assessing air quality impacts of reducing fossil gas use, and analyzing location-specific data to identify promising candidate pilot sites for infrastructure decommissioning. The research on prospective decommissioning pilot sites suggests that implementing conversions of energy equipment from using fossil gas to cleaner alternatives in a manner coordinated with near-term decommissioning of pipeline segments will be challenging. Legacy practices from past energy policy efforts, such as encouraging change in how consumers make energy decisions by providing information and incentives for efficiency, will help but are not adapted to the scale, intensity, or level of coordination required for the gas energy transition envisioned by the state.

Moreover, while COVID-19 is no longer considered a public health emergency, supply chains for energy equipment are not fully recovered, and economic repercussions remain. Plus, people and institutions are still adapting to climate change and the energy stresses it causes, and that process is slow, unpredictable, and ongoing.

These conditions create a need for empirically based assessments illuminating options for paths ahead. These assessments include ways to encourage and support technological change at the end-use level and, in turn, how these changes can effectively be coordinated with infrastructure changes and resource planning; ways to handle hard-to-electrify end uses or situations (such as specific cases with prohibitive conversion costs or special resilience challenges); and the benefits and costs of the gas transition for energy users, energy security, system safety, and resilience overall. Research supported under this initiative will inform these

pathways based on ongoing experience in decarbonizing the gas system and by coordinating across disparate components of gas transition research and planning.

Initiative Theme: Gas System Safety

California's gas system provides service to more than 11 million metered customers through an extensive network of nearly 12,000 miles of transmission pipelines and more than 300 underground gas storage wells. [31] [32] While California is working to transition end uses such as buildings and transportation to electricity, maintaining robust storage and transmission infrastructure plays an important role in ensuring system reliability and protecting customers from adverse rate impacts in the electricity and gas sectors. In addition, at this juncture of California's clean energy transition, gas storage wells remain important to provide a stable supply of gas during periods of peak winter demand and continue to fill a critical role in balancing the intermittency of renewable electricity generation.[33]

The urgency of gas system safety becomes even more critical in light of California's aging gas system, which increases the risk of vulnerabilities and potential system failures. Events such as the 2015 Aliso Canyon leak and 2010 San Bruno pipeline explosion are reminders of the importance of prioritizing public safety, public health, and emissions considerations in gas system research and planning. In the aftermath of these major incidents, more stringent safety regulations have been issued by the California Geologic Energy Management Division (CalGEM) and the U.S. DOT Pipeline and Hazardous Materials Safety Administration (PHMSA), requiring additional tests and inspections to ensure system safety and integrity.

The gas system is becoming increasingly costly to maintain due to aging infrastructure, safety regulations, and decreasing gas usage, the latter of which may also create a gap in cost recovery.[34] To reduce costs during this transition while ensuring safety and reliability, the Gas R&D Program has historically coordinated with gas IOUs and funded research in developing innovative tools and technologies to better assess system vulnerability and prevent damages from geohazards, excavation, corrosion, and other threats. The Gas R&D Program complements research conducted by industry and gas utilities, helping address public safety and affordability issues in the context of achieving the state's climate goals.

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31 California Public Utilities Commission. "*Natural Gas and California*," https://www.cpuc.ca.gov/industries-and-topics/natural-gas/natural-gas-and-california.

32 Pipeline and Hazardous Materials Safety Administration. "*Pipeline Mileage and Facilities*," https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities.

33 California Public Utilities Commission. 2023. "*Decision on Phase 2 Issues Regarding Transmission Pipelines and Storage,"* https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M521/K892/521892086.PDF.

34 Aas, Dan, Amber Mahone, Zack Subin, Michael Mac Kinnon, Blake Lane, and Snuller Price. Energy and Environmental Economics, Inc. California Energy Commission. "*The Challenge of Retail Gas in California's Low-Carbon Future*." Publication Number: CEC-500-2019-055-F, https://www.ethree.com/wp-content/uploads/2021/06/CEC-500-2019-055-F.pdf.

Initiative Title: Innovations for Cost-Effective Operation and Maintenance of Critical Infrastructure During the Gas Transition

Initiative Description

This initiative will build on prior CEC research to improve the costs, accuracy, and data quality in operations and maintenance of underground gas storage wells and transmission pipelines by developing strategies and resources, such as continuous monitoring technologies, less intrusive inspection methods, and data management and communication systems. Research conducted under this initiative may include:

- Developing more accurate and reliable monitoring technologies that can detect anomalies in underground storage wells without needing invasive and costly conventional well inspections, thereby improving system safety while minimizing disruptions to operations.
- Optimizing alternative well inspection frequencies by improving data quality and models to estimate degradation trajectory and improving understanding of how inspection techniques may impact well integrity.
- Advancing nondestructive testing methods to verify the material properties of gas pipelines, thus reducing the need for costly excavations or testing methods that disrupt pipeline operations.
- Improving in-line inspection technologies for small-diameter transmission pipelines, which can be particularly challenging to inspect due to size and complex geometry.
- Supporting integration of data management and communication technologies, including asset tracking and traceability, situational awareness systems, and tools supporting documentation and analysis of human factors in managing risk.

Expected Outcomes

Technologies developed under this initiative will support safer and more cost-effective methods of meeting gas system operations and maintenance requirements and inform more optimal prioritization and frequency of inspections. Among the advancements, less intrusive well inspection and monitoring technologies may include fiber optic, acoustic, and electromagnetic sensors that can detect anomalies in mechanical well barriers. Furthermore, less intrusive well inspections can reduce costs by improving system capacity and decreasing reliance on redundant infrastructure. Enabling earlier responses to well integrity risks before more major intervention is needed will improve system safety and help to maintain capacity.

Furthermore, the initiative explores nondestructive pipeline material verification and small-diameter in-line inspection such as ultrasonic, radiographic, and electromagnetic devices that can measure wall thickness, detect cracks, and detect corrosion damage in gas pipelines. These technologies will enable more rapid testing of the gas transmission system to help protect vulnerable communities and guide derating and decommissioning decisions.[35]

35 *Derating* means to decrease the capacity or operating limits of an asset due to aging or degradation of the asset, or to extend the asset's useful life.

Integration of data management and communication technologies will help operators leverage monitoring and inspection data to optimize operations and maintenance.

Benefits to Californians

As the gas system transitions and end uses are electrified, operations and maintenance of the gas system will remain complex and costly. Development of accurate and reliable technologies for assessing integrity and detecting anomalies in storage wells and transmission lines will help ensure safe, reliable, and affordable operation while minimizing environmental impacts.

- **Adaptation:** Considering the interdependencies of the gas and electric sectors, operation and maintenance of transmission pipelines and underground gas storage facilities will continue to play a crucial role in protecting ratepayers from reliability and adverse rate impacts in the gas and electric sectors as California transitions away from fossil gas.
- **Affordability:** As gas demand declines to help achieve the state's climate goals, fewer ratepayers will be assigned the costs to maintain the aging gas system. Reducing maintenance costs can help avoid adverse affordability impacts to ratepayers during this transition. This initiative will support innovations for alternative inspection methods that avoid restricting gas system capacity, which can also result in higher costs for ratepayers by reducing supply and requiring system redundancies.
- **Safety and reliability:** Detecting threats in real time will allow operators to intervene before issues escalate into significant safety concerns. Proactive and targeted responses minimize the risk of equipment failure or other incidents that could disrupt service or result in costly consequences for ratepayers and surrounding communities.
- **Equity:** Lowering potential risks to transmission pipelines and underground gas storage facilities is critical for protecting surrounding communities that may be subject to disproportionate impacts from incidents, environmental damage, and the high costs of equipment repairs and disaster recovery. Lowering the costs of risk mitigation helps improve affordability for all ratepayers.
- **Environmental sustainability**: Current pipeline and well inspection methods require systems to be taken offline for inspection, requiring redundant gas infrastructure to remain in operation to maintain capacity. Less intrusive methods will reduce downtime and help minimize the footprint of the gas system. Moreover, early identification of potential issues such as leaks or structural weaknesses can guide prompt mitigation efforts, reducing environmental impacts.

Rationale

CalGEM's Requirements for Underground Gas Storage Projects went into effect in 2018 and require, in addition to annual noise and temperature logging, well casing wall thickness inspection and pressure testing every 24 months unless an alternative interval is approved by

CalGEM.[36] Conventional means of performing well inspections require the well to be shut off and instruments to be lowered into the well to make measurements and detect anomalies. Pressure testing is performed to verify structural integrity. Maintenance plans to meet CalGEM requirements are projected to cost hundreds of millions of dollars through 2030, delay the decommissioning of the Los Medanos storage field in Contra Costa County, and require new wells to be drilled to maintain capacity requirements.[37] In addition, conventional inspections carry safety risks because of human factors, reliability of inspection equipment, and complexity of tasks.[38]

In coordination meetings with CalGEM, CEC and CalGEM staffs have discussed potential research and technology approaches to addressing these challenges faced by gas IOUs, including improving emerging less-intrusive inspection and monitoring technologies to accurately identify anomalies, as well as better understand factors for determining alternative inspection intervals.

PHMSA's Mega Rule, which took effect in 2019, requires pipeline operators to reconfirm maximum allowable operating pressure, verify pipeline material properties, and perform integrity assessments based on criteria such as existing data, location, and operating pressure of the pipeline.[39] These regulations affect more than 1,000 miles of California's transmission pipelines and will be more costly than preceding regulations.[40] CEC staff intends to stay coordinated with PHMSA's Pipeline Safety Research and Development Program and explore opportunities to build off early-stage research funded by PHMSA to accelerate implementation in California. Research is needed to develop more cost-effective methods for meeting the current PHMSA and CalGEM requirements.[41] In addition, data collected could guide future policy decisions on gas system operation and maintenance requirements.

Technology and Market Background

In addition, prior CEC-funded projects have collaborated with PG&E to demonstrate real-time monitoring of underground gas storage wells with the use of fiber optics and less-intrusive

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36 California Department of Conservation. "*Geologic Energy Management Underground Gas Storage Regulations*," https://www.conservation.ca.gov/calgem/general_information/Pages/UGSRules.aspx.

37 CPUC. May 2023. "*Senate Bill 695 Report*," https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2023/2023-sb-695-report---final.pdf.

38 California Department of Conservation. 2022. "*Statutes and Regulations*," https://www.conservation.ca.gov/index/Documents/CALGEM-SR-1%20Web%20Copy.pdf.

39 PHMSA. 2019. "*Pipeline Safety: Safety of Gas Transmission Pipelines: MAOP Reconfirmation, Expansion of Assessment Requirements, and Other Related Amendments*," https://www.federalregister.gov/documents/2019/10/01/2019-20306/pipeline-safety-safety-of-gas-transmission-pipelines-maop-reconfirmation-expansion-of-assessment/.

40 California Public Utilities Commission. 2023. (Table 23). "*Senate Bill 695 Report*," https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2023/2023-sb-695-report---final.pdf.

41 U.S. Department of Transportation. "*Pipeline Research & Development*," https://www.phmsa.dot.gov/research-and-development/pipeline/about-pipeline-research-development

inspections with electromagnetic technologies.[42] Building upon this work, advancements in existing and novel real-time monitoring and data management technologies can enable faster intervention and proactive maintenance. By providing operators with accurate, more granular, and timely data about the condition of their assets, they will be better able to identify potential issues before they become major problems or hazards. These data allow for quicker response times when needed as well as more proactive maintenance strategies that can help prevent costly repairs or replacements. Real-time monitoring can provide insights into operational performance, which may be used to guide decision making related to future investments and decommissioning, but research is needed to improve data quality and reduce costs.

Less intrusive inspection technologies can reduce the need for conventional well inspections, which are required due to current regulations. Conventional inspections are resource-intensive, requiring the well to be shut off as specialized equipment enters the well to perform a series of tests. Well entries pose significant risks to well integrity because of the potential for equipment failure or human error. Minimizing well entry frequency and using less invasive entry methods are associated with lower operating risks over the life of the well.[43] Less intrusive methods can provide useful information to determine well integrity while reducing or eliminating well shutoff durations, thereby avoiding capacity impacts to the system. Additional research is needed to understand the human factors in well inspection safety, develop less intrusive inspection technology alternatives, and optimize inspection frequency with robust risk assessments.

Nondestructive testing can provide accurate information about the integrity and material properties of transmission pipelines with minimal disruption to gas service.[44] Surface testing such as microindentation can be used to obtain information about yield strength and other mechanical properties of pipeline materials without needing to shut off or remove portions of the pipeline.[45] Inline inspection technologies such as magnetic flux leakage are used to examine pipeline walls without requiring direct access to the full length of the pipeline.[46] Inline inspection can detect subcritical flaws and provide data used in reconfirming maximum allowable operating pressure.[47] Improved inline inspection technologies for small-diameter transmission pipelines can aid in inspecting pipelines that are too narrow or have geometry

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42 Agreement PIR-19-001. "*All-Optical Multi-Sensor Well Monitoring System to Secure Gas Storage Operations*" and PIR-19-002 "*Electromagnetic and Optical Sensor Technologies for Natural Gas Storage Safety Monitoring*."

42 C-FER Technologies. 2020. "*Risk Assessment and Treatment Wells*," https://rosap.ntl.bts.gov/view/dot/56180.

44 *Nondestructive testing* is a group of testing methods that evaluate the properties of a material, component, or system without causing damage.

45 GTI Energy. 2021. "*Validating Non-Destructive Tools for Surface to Bulk Correlations of Yield Strength, Toughness, and Chemistry,"*
https://primis.phmsa.dot.gov/matrix/FilGet.rdm?fil=15889&s=59804F6060A24393B2C4804836990D47&c=1.

46 *Magnetic flux leakage* is a nondestructive testing method that uses magnetic fields to detect defects in steel structures.

47 PHMSA. 2019. "Pipeline Safety: Safety of Gas Transmission Pipelines: MAOP Reconfirmation, Expansion of Assessment Requirements, and Other Related Amendments,"
https://www.federalregister.gov/documents/2019/10/01/2019-20306/pipeline-safety-safety-of-gas-transmission-pipelines-maop-reconfirmation-expansion-of-assessment.

that is too complex for current in-line inspection technologies. Additional research is needed to improve the versatility, data reliability, and analysis methods of nondestructive testing to reduce the need for more disruptive and destructive testing.

Initiative Theme: Renewable Generation

In 2022, California's power sector generated more than 36 percent of its energy from fossil gas that contributed to nearly 16 percent of the state's greenhouse gas (GHG) emissions.[4849]The transition to a cleaner energy system requires adaptable power generation solutions that can remain efficient and reliable. An important piece of that puzzle could be fuel-flexible distributed power generation to bolster resiliency while providing clean energy access to vulnerable communities, especially during extreme weather and grid events.[50] Clean distributed generation aligns with the goals in Senate Bill 100 (De León, Chapter 312, Statutes of 2018), which mandates a transition to 100 percent renewable energy and zero-carbon resources by 2045.[51] In line with these goals, California is in a rapidly evolving phase in which increased adoption of renewable gases, such as hydrogen, biomethane, or ammonia, is being considered, and this consideration may create a fluctuation of mixtures in the gas fuel stream. Fuel-flexible generation can also help achieve goals under Assembly Bill 205 (Ting, Chapter 61, Statutes of 2022), which created the Strategic Reliability Reserve to support the state's electric grid reliability for technologies like those developed under this initiative.[52] [53]

The CEC is funding hydrogen-blended generation research to develop and demonstrate GHG and oxides of nitrogen (NOx) emissions-mitigating technologies in gas-fired systems. In contrast, this initiative focuses on developing combustion and non-combustion generation technologies to be flexible for using either a single renewable fuel or mix of renewable fuels demonstrated in distributed generation applications. The fuel-flexible technology innovations developed under this initiative would allow for decarbonization strategies that use different fuels based upon the availability and costs of the renewable fuel and the fuel blending infrastructure.

This research initiative complements the distributed generation decarbonization work of IOUs, publicly owned utilities (POUs), and industry to propel California toward a net-zero-carbon

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48 California Energy Commission. 2022. "*2022 Total System Electric Generation*", https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2022-total-system-electric-generation.

49 California Air Resources Board. 2023. "*Current California GHG Emission Inventory Data*. 2000-2021 GHG Inventory (2023 Edition)." https://ww2.arb.ca.gov/ghg-inventory-data.

50 *Fuel-flexible distributed power generation* means having distributed systems capable of using a wide range of decarbonized fuels and fuel blends.

51 Senate Bill 100. 2018. *Bill Text: CA SB100 | 2017–2018 | Regular Session*, https://legiscan.com/CA/text/SB100/id/1819458.

52 Bill Text: CA AB205 Energy | Chapter 61|. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB205.

53 California Energy Commission. "Distributed Electricity Backup Assets Program," https://www.energy.ca.gov/programs-and-topics/programs/distributed-electricity-backup-assets-program.

energy future. Following that, the CEC shares information pertaining to research projects and goals with SoCalGas and PG&E and plans to increase frequency and broaden engagement of these efforts, to avoid unnecessary duplication. This collaboration ensures that funding from the Gas R&D program is being strategically used in areas that are best supported by ratepayer funds.

Initiative Title: Fuel-Flexible Distributed Power Generation

Initiative Description

This initiative will result in development and demonstration projects that can take distributed generation technologies, such as reciprocating engines, gas turbines, linear generators and fuel cells, and make them adaptable to the anticipated changing fuel supply. [54] [55] [56] [57], Innovations are needed at the component level up to the system level to ensure that the fuel-flexible technologies will meet the performance, operability, cost, low-emissions, and decarbonization goals and targets.

Expected Outcomes

Successful projects funded under this initiative will advance the development of clean distributed generation systems to align with California's decarbonization goals while ensuring reliable performance. Outcomes include achieving emission levels below the maximum regulatory thresholds, increasing fuel efficiency, reducing costs, and delivering resilience. Demonstrations may involve either deploying new installations that use electrochemical, thermochemical, or other proven pathways with very low emissions even without being dependent on emissions control technologies, or modifying existing combustion systems, whereby each demonstration would greatly reduce GHG and criteria pollutants and have other public health impacts.

The inclusion of combustion systems is needed to allow investment in a mixed technology scenario for a decarbonization approach that reduces risk and enables a faster, more cost-effective transition. Modifying existing combustion systems to operate on renewable fuels would enable use of existing engine platforms that could tolerate potential fuel impurities while operating reliably and ensuring low emissions. The intention is for adapting and scaling up distributed generation systems to be used as added generation support, and to locate systems carefully and strategically at commercial or industrial sites that avoid negatively impacting disadvantaged or low-income communities.[58] Given the potential scarcity of renewable fuels,

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54 *Reciprocating engine* is an engine in which expanding combustion gases move one or more pistons up and down in cylinders.

55 *Gas turbine* is an engine in which expanding combustion gases spin the blades of a turbine.

56 *Linear generator* is a device that uses a low temperature thermochemical reaction to create linear motion that is directly converted into electricity, as defined under Rule 1110.2 of South Coast AQMD. Refer to: https://www.aqmd.gov/docs/default-source/rule-book/reg-xi/r1110_2.pdf?sfvrsn=8

57 *Fuel cell* is a device that uses an electrochemical reaction to directly generate electricity.

58 PSE Healthy Energy. May 2020. "*California Peaker Power Plants,"* https://www.psehealthyenergy.org/wp-content/uploads/2020/03/California.pdf.

potential projects must secure a reliable fuel source. Project outcomes could provide valuable information for the future adoption of technologies as renewable fuels become more widely available.

CEC staff anticipates that research results and technology advancements will benefit diverse sectors, including commercial buildings and industrial operations, utilities, and communities in remote or rural locations, especially those not connected to the grid. Critical infrastructure, like data centers, hospitals, microgrids, telecommunications, and others that need to ensure continuous operations, especially during grid outages, are of particular interest as demonstration sites, as these fuel-flexible generation technologies have the potential to replace diesel backup generators and greatly reduce concomitant pollutants.

Benefits to Californians

Fuel-flexible generation technologies would be designed for consistent operation amid fluctuating availability and types of renewable fuels. The scalability and modularity of these technologies could increase associated adaptability to changing energy needs and lead to reduced costs through mass production or lower design and implementation costs. Projects can optimize capital and operational costs of power generation technologies by diversifying fuel sources. The ability to switch among different fuel types will allow operation to optimize the most cost-effective renewable fuels, especially as the overall costs of renewable fuels decrease. This effort also contributes to addressing Goal 2.4 in the CPUC Environmental and Social Justice Action Plan, as it can reduce pollutant impacts in environmental and social justice communities.[59]

- **Adaptation:** Enable technologies that can adjust to the different renewable fuel types that may be available as the fuel streams transition from fossil to renewable gases, thereby supporting reduced reliance on centralized power plants and strain on the grid while enabling distributed generation for local use.
- **Affordability:** Optimize capital and operational costs of power generation technologies by enabling fuel diversification, leveraging cost-effective renewable fuels, enhancing efficiency beyond that of traditional fossil gas technologies, minimizing transmission losses, and capitalizing on scalable, modular designs. In addition, distributed generation enables reduced transmission losses, which ultimately contributes to lowered energy costs to consumers.
- **Reliability and integrity:** Enhance energy reliability and grid stability by ensuring consistent operation with various renewable fuels, decentralizing power generation to boost resilience, and potentially replacing traditional backup systems used during outages or peak demand to ensure reliable, on-demand power for communities.

59 California Public Utilities Commission. 2022. "*Environmental & Social Justice Action Plan,"* https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/news-and-outreach/documents/news-office/key-issues/esj/esj-action-plan-v2jw.pdf.

- **Safety:** Increase resilience to equipment failures, unplanned outages, and fuel slip or leaks. In addition, the initiative supports development of safe handling practices for using different fuel types in the generation system.
- **Equity and environmental sustainability:** Reduce GHG and criteria pollutant emissions compared to fossil gas generation technologies, particularly when deployed in under-resourced communities that are often disproportionately affected by pollution. These technologies would reduce reliance on fossil gas and encourage a transition to renewable fuels with ultra-low-to-zero emissions.

Rationale

The California Air Resources Board's 2022 Scoping Plan and SB 100 emphasize the need for adaptable generation systems to withstand the decarbonization trajectories and help to eliminate use of fossil fuels. Fuel changes ordered under Senate Bill 1440 (Hueso, Chapter 739, Statutes of 2018) resulted in proceedings such as the 2022 CPUC Decision 22-02-025that are anticipated to cause a significant increase in biomethane entering the gas pipeline system (up to 72.8 billion cubic feet per year by 2030) to help achieve a 40-percent reduction in methane emissions.[60] [61] Furthermore, with the significant federal investments, particularly from the Infrastructure Investment and Jobs Act for ARCHES and the Inflation Reduction Act for the Clean Hydrogen Production Tax Credit, production and use of hydrogen are expected as the price of clean renewable hydrogen decreases.[62] [63] [64]

The *2022 IEPR Update* recommended expanding SB 100 analyses to evaluate increased hydrogen use to decarbonize fossil gas-fired generation, as well as promote new economic opportunities such as green ammonia.[65] [66] Recommendations in the *Draft 2023 IEPR* highlighted the need for continued research and development on clean and renewable

60 Senate Bill 1440. Hueso. 2018. "*Bill Text: CA SB-1440 Energy: biomethane: biomethane procurement,"* |https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1440.

61 California Public Utilities Commission. 2022. "*Order Instituting Rulemaking to Adopt Biomethane Standards and Requirements, Pipeline Open Access Rules, and Related Enforcement Provisions."* docs.cpuc.ca.gov/PublishedDocs/Published/G000/M454/K335/454335009.PDF.

62 Congress Gov. *H.R.3684 — 117th Congress (2021-2022): Infrastructure Investment and Jobs Act. November 15, 2021,* https://www.congress.gov/bill/117th-congress/house-bill/3684.

63 Araches H2. "*Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES),"* https://archesh2.org/.

64 Text — H.R.5376 - 117th Congress (2021-2022): Inflation Reduction Act of 2022. August 16, 2022, https://www.congress.gov/bill/117th-congress/house-bill/5376/text.

65 California Energy Commission Staff. 2023. *Final 2022 Integrated Energy Policy Report Update*.. Publication Number: CEC-100-2022-001- CMF, https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2022-integrated-energy-policy-report-update.

66 *Green ammonia* also known as renewable ammonia, is a form of ammonia that is produced using renewable energy sources.

hydrogen generation to improve efficiency, address NO_x formation, and understand materials impacts, especially at higher blends.[67]

IOUs such as SoCalGas and SDG&E are investing in research demonstrations for producing, transporting, storing, and blending for various end uses and have plans for using clean hydrogen in their generation portfolios.[68] [69] POUs, such as LADWP, intend to have their generating station units run on 100 percent green hydrogen by 2035.[70] For ammonia, international companies are investing in end uses, such as Japan's largest power generation company, JERA, which is partnering with Mitsubishi to establish a 100 percent ammonia power plant.[71] Renewable ammonia and renewable methanol are more nascent compared to renewable hydrogen and biomethane but show potential for use either directly in gas turbines or as a pathway to produce renewable hydrogen.[72]

Furthermore, there is emerging interest in both for industrial operations, such as chemical manufacturing, and backup power due to easier storage compared to hydrogen. Industries are generally risk-averse, and CEC's support in continuing the development of power generation technologies can help reduce associated risks. Therefore, with policy and industry drivers in action, there is a clear need for investing in fuel-flexible technology innovations.

This need is supported by the recommendations in analysis, *Recommendations for the Long-Term Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals,* conducted by Guidehouse, that identified challenges in using renewable fuels that may vary in quality, composition, and characteristics. Other challenges included the use of renewable fuels in distributed generation applications, such as those in remote areas, where electrification may not always be suitable or affordable and fuel-flexible generation options may be needed to fit those demands. This initiative seeks to ensure that existing fossil gas-fired technologies are quickly and effectively modified or replaced, in alignment with Governor Gavin Newsom's 2022

67 California Energy Commission Staff. 2023. *Draft 2023 Integrated Energy Policy Report*. Publication Number: CEC-100-2023-001-CMD, https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2023-integrated-energy-policy-report.

68 SoCalGas. *"Angeles Link: Shaping the Future With Clean Renewable Hydrogen,"* https://www.socalgas.com/sustainability/hydrogen/angeles-link.

69 SDGE. "*Hydrogen Innovations,"* https://www.sdge.com/more-information/environment/sustainability-approach/hydrogen-innovation.

70 LADWP. "*Scattergood Generating Station Units 1 and 2 Green Hydrogen-Ready Modernization Project*," https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-power/a-p-projects/a-p-p-scattergoodmodernization?_adf.ctrl-state=17iye60ga_4&_afrLoop=921049590252480

71 JERA. *"Jurong Port, Mitsubishi Heavy Industries Asia Pacific and JERA Asia come together… to explore establishing an ammonia direct combustion power plant. The project aims to accomplish the twin goals of supplying green electricity and developing an ammonia bunk,"* https://www.jera.co.jp/en/news/information/20220819_961.

72 IEA for the G20. Japan. June 2019. "*The Future of Hydrogen."* https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf.

Fairley, Peter. IEEE Spectrum. October 31, 2023. "*Backing Up the Power Grid With Green Methanol."* https://spectrum.ieee.org/methanol-energy-storage.

letter requesting state agencies to plan for no new fossil gas-fired plants to meet long-term energy goals. [73]

While renewable fuel blends will impact the performance and associated emissions of a technology, which is a specific concern raised by DACAG, this initiative aims to introduce new installations that use electrochemical, thermochemical, or other proven pathways, with very low emissions even without being dependent on emissions control technologies or modify existing combustion systems that could help to improve local air quality and public health.

Technology and Market Background

Existing power generation technologies are not designed to operate with flexible fuel blends and cannot readily withstand changes to fuel inputs. Taking a technology-neutral approach could enable a quicker and more cost-effective decarbonization transition. Innovation options could include developing new sensors and controls, modifying fuel handling systems, and refashioning combustor hardware to handle a variety of operations, such as steady-state and transient operations, to investigate fully the performance and emissions impacts under different modes.[74]

While efforts exist to introduce renewable fuels in power generation technologies, the goal of this initiative is to enable a broader array of renewable fuel types, including mixes, than presently deployed. For hydrogen, the CEC is funding projects focused on combustion-based power generation systems that can use a steady volumetric percentage of higher blends of hydrogen and demonstrate low NO_x and GHG emissions.[75] The U.S. Department of Energy awarded several projects nationally to develop equipment capable of using low-carbon fuels like hydrogen and hydrogen blends with a specific focus on industrial decarbonization.[76] However, as these projects would not solely use renewable fuels, research is needed on a wide range of generation technologies that can more adequately adapt to California's anticipated fuel changes and climate commitments.

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73 Office of the Governor. 2022. "*Letter from Governor Gavin Newsom to CARB Chair Liane Randolph.*" https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf?emrc=1054d6

74 *Steady-state Operations* assumes that the system does not change over time, while *Transient Operations* considers the changes that occur over time.

75 California Energy Commission. 2023. "*GFO-22-504 — Hydrogen Blending and Lower Oxides of Nitrogen Emissions in Gas-Fired Generation (HyBLOX).*", https://www.energy.ca.gov/solicitations/2023-01/gfo-22-504-hydrogen-blending-and-lower-oxides-nitrogen-emissions-gas-fired.

76 Office of Energy Efficiency & Renewable Energy. *" Funding Selections: FY23 Industrial Efficiency and Decarbonization Multi-Topic FOA,"* https://www.energy.gov/eere/iedo/funding-selections-fy23-industrial-efficiency-and-decarbonization-multi-topic-foa.

For biomethane, companies such as MTU, Jenbacher, Caterpillar, and 2G-Energyare developing new biogas-capable generation systems.[77] [78] [79] [80] However, the focus of this initiative is different from that of the industry developers, as it seeks to support modifications on existing gas-fired generation systems. For ammonia, companies like GE see the need for multi-year investments to develop ammonia-capable gas turbines that meet critical operational and safety requirements.[81] To leverage such ongoing work and address the remaining research gaps, this initiative looks at the innovation space much more broadly across fuels and power generation systems and would require ultra-low to zero-GHG emissions and criteria pollutants, such as NO_x and CO, be demonstrated.

Initiative Theme: Building Decarbonization

Residential and commercial buildings collectively contribute 25 percent of GHG emissions in the state, considering both the fossil fuels consumed onsite and those used to generate electricity for buildings. Promptly and cost-effectively decreasing these emissions is crucial to achieving California's GHG reduction and climate objectives, as outlined in the CEC's *California Building Decarbonization Assessment.*[82] Among the identified approaches for GHG reductions and decarbonization in the building sector, two key strategies stand out: building end-use electrification and the integration of distributed energy resources. These measures aim to address the significant environmental impact of buildings and contribute to a sustainable and low-carbon future.

Geothermal heating can fill an important gap in phasing out fossil fuel use in the building sector. In California, geothermal power relies on known geothermal areas to provide high-pressure steam to produce electricity. DOE grants and other efforts are exploring geothermal heating and cooling throughout the country.[83] [84] For many of these projects, including a recent Geo-Grid system in Colorado, the technology considered is also referred to as a *ground-source heat pump* or *geo-exchange*, as it would use the relatively constant temperature of the

77 MTU. "*The New Biogas Systems mtu Series 4000,"* https://www.mtu-solutions.com/na/en/applications/power-generation/power-generation-products/gas-generator-sets/biogas-generator-sets.html.

78 Jenbacher. "*Biogas: Turning Biogas Into Heat and Power,"* https://www.jenbacher.com/en/energy-solutions/energy-sources/biogas.

79 CAT. *"Higher Efficiency, Lower Cost, Renewable Energy,"* https://www.cat.com/en_US/by-industry/electric-power/electric-power-industries/biogas-higher-efficiency.html.

80 2G. *"Biogas,"* https://www.2g-energy.com/products/biogas.

81 GE. *"Ammonia as a Power Generation Fuel,"* https://www.ge.com/content/dam/gepower-new/global/en_US/images/gas-new-site/future-of-energy/GEA34985-ammonia-power-gen.pdf.

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

83 U.S. Department of Energy. April 25, 2023. Press release. *"DOE Announces $13 Million to Support Community Geothermal Heating and Cooling Solutions,"* https://www.energy.gov/articles/doe-announces-13-million-support-community-geothermal-heating-and-cooling-solutions.

84 California Energy Commission. "*Geothermal Grant and Loan Program,"* https://www.energy.ca.gov/programs-and-topics/programs/geothermal-grant-and-loan-program.

subsurface to heat and cool efficiently.[85] However, for California, ground-source heat pump networks may be challenging to implement due to the amount of land needed to support nearby buildings with complementary heating and cooling loads. Population centers in California would benefit from accessing higher-quality geothermal resources that are deeper than what is used for ground-source heat pumps.

Initiative Title: Networked Geothermal District Heating Study

Initiative Description

This initiative will study and develop opportunities for geothermal energy sourced deeper than geo-exchange and shallower than power generation to provide economical, large-scale, zero-carbon heating for district heating systems, via a two-phased approach.

Phase I aims to enhance understanding of the potential applications of geothermal district heating in buildings and campuses that are challenged to electrify. A comprehensive study of the latest advancements in drilling technology and California's geological conditions would thoroughly examine the capabilities, costs, and environmental impacts associated with cutting-edge drilling technologies for mid-depth geothermal energy. The study would seek to apply this understanding to identify high-potential areas for geothermal district heating and match them with opportunities for specific buildings and campuses in California that could serve as potential demonstrations of the technology.

The outcomes of Phase I will result in the development of a feasibility tool, supported by the collected data, that would enable stakeholders to estimate costs and benefits when considering using geothermal resources in their respective locations. The study would also investigate the feasibility of leveraging the existing gas utility workforce, recognizing the potential expertise within local workforces, for implementing geothermal district heating systems.

In Phase II, projects will demonstrate the most promising technology for drilling a new mid-depth well or modifying an existing well at one or two suitable sites, based on the findings from Phase I. The projects will implement the tools developed and technologies evaluated in the preceding phase. Phase II will also include comprehensive testing of existing oil and gas wells in the field throughout California, as informed by CalGEM. Many of these wells are no longer in production, and they are deep enough to be used to obtain information on geothermal resources. Importantly, numerous wells are located within or near population centers.

Evaluation of these potential locations may reveal that they could be modified or improved to geothermal heating. Considerations will be given to geological factors, concerns related to induced seismicity, building or campus characteristics (or both), and proximity to densely populated areas that may struggle to electrify and stand to derive significant benefit from a long-term, carbon-free heating source.

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85 Colorado Mesa University. *"Geo-Grid System,"* https://www.coloradomesa.edu/sustainability/initiatives/geo-grid.html.

Expected Outcomes

One anticipated outcome of this study is to identify the most promising locations, using CalGEM and other data resources, for accessing and optimizing geothermal energy for district heating. While known geothermal resource areas offer easily accessible heating, this research will delve into other regions that conventionally were not deemed suitable, due to the need for deeper drilling or other geologic or community factors influencing site success but may now offer significant opportunities because of recent advancements in drilling technologies. This mapping would identify and enhance the effectiveness of subsequent demonstration projects in Phase II.

The study will thoroughly examine potential existing district heating sites, local geology, existing oil and gas wells, the latest drilling technology, and potential future district heating locations in densely populated areas to identify pilot sites that offer the most valuable insights for replicability and scalability. These selected sites shall represent areas where success is highly probable, aiming to provide a roadmap for optimal implementation. Simultaneously, the study will consider locations where challenges may be encountered, helping develop a comprehensive understanding of the feasibility spectrum and support strategic decision-making to advance the deployment of, and accessibility to, geothermal district heating.

The study outcomes will guide the second phase of the project, whereby the technology will be demonstrated at field sites. The demonstration sites will be selected to gain the most insight into the challenges and economics of geothermal heating in areas that may have previously been overlooked. These may include sites near existing district heating facilities that have an existing gas well that needs to be modified, with geological conditions that are easier to drill because of new technology, or that are brownfield sites. Potential outcomes could be productive uses of previously low-value real estate and lower, more predictable building energy costs. The emphasis will be on showcasing the drilling technology and ways that might be replicable in all or most of California, especially in densely populated areas. A successful demonstration in Phase II would help validate that other locations could leverage the tool CEC staff has developed to assess the cost-effectiveness and benefits of implementing networked geothermal for district heating.

Benefits to Californians

Benefits include a reduction in dependence on fossil gas, decreased emissions in underresourced communities, diminished reliance on existing grid services, enhanced safety through the elimination of aging gas infrastructure, and more predictable utility costs. The trajectory of the gas system and labor force faces uncertainty amid decarbonization and electrification initiatives that may place financial burdens on less affluent ratepayers and a diminishing workforce. Successful implementation of the project could help to mitigate these challenges in the future and encourage the consideration of a role for gas utilities in the supply of thermal energy to ratepayers. The study will delve deeper into identifying the scope of benefits and exploring the suitability of the technology for existing district heating sites in urban areas, new construction, neighborhood retrofitting, or less densely populated areas burdened by costly infrastructure.

- **Adaptation:** Enable an alternative pathway to achieving resilient and reliable zero-emission heating, particularly for district heating systems that have few options for electrification. It may also present an opportunity for gas utility companies to diversify as they assist in the energy transition and avoid increased costs for ratepayers remaining longer on the gas system, who are likely to be lower income.
- **Affordability**: Open up opportunities for utility or other third-party financing models that could stabilize heating costs via a fixed rate that is more resilient to inflation or changing fuel costs.
- **Safety and reliability:** Reduce demand for fossil gas and stress on the electric grid. Potentially increases the safety and efficiency of heating systems for residential and commercial ratepayers that currently rely on combustion.
- **Equity:** Reduce GHG and criteria pollutant emissions in underresourced communities often disproportionately affected by pollution.
- **Environmental sustainability:** Reduce reliance on fossil gas and encourages transition to renewable resources.

Rationale

Major gas consumers — such as hospitals, university campuses, and large commercial buildings served by central plants — face the imperative of exploring pathways for decarbonization. Typical heat pump technologies, including air-source and ground-source, may not be cost-effective or may have limitations on applications such as market availability of larger-sized equipment or commercially available technology for steam generation. Recent advancements in drilling technology, stemming from the hydraulic fracturing industry, have elevated the feasibility of geothermal power generation even in areas previously deemed less geologically favorable. Innovations like millimeter wave and directional drilling technology is enhancing the cost-effectiveness of geothermal power.[86] [87]

During the CPUC PICG EPIC Strategic Goals Built Environment Workshop held September 20, 2023, Mark Toney of The Utility Reform Network suggested researching geothermal district heating. Suggestions included using R&D to reduce geothermal drilling costs, resulting in reduced emissions and costs to ratepayers. The CPUC also joined a Gas R&D Working Group Meeting on September 26, 2023, following the PICG workshop, where networked geothermal research was suggested under EPIC. The CEC asked the CPUC if this topic fit better under Gas R&D or EPIC and were told it could work for either, emphasizing the potential for reducing heat pump loads in winter.

86 https://www.arpa-e.energy.gov/technologies/projects/millimeter-wave-technology-demonstration-geothermal-direct-energy-drilling.

87 https://www.energy.gov/eere/geothermal/articles/fervo-energy-sets-stage-accelerating-geothermal-deployment-successful-well

Technology and Market Background

Distinguishing itself from typical ground-source heat pump loops with shallow bores under 100 meters that cater to heating and cooling, geothermal power for high-energy needs requires ideal conditions or deep well drilling ranging from 1500 to 3000 meters. Given that buildings typically demand less heat than power generation, a mid-depth strategy could be employed that borrows from both, deep drilling aimed at heating rather than power generation. This strategy could expand and improve the quality of heat sources available and cost-effectively heat buildings using geothermal sources.

The research focus in this initiative is on generating low-pressure steam or high-temperature water near population centers from drilling within the 100- to 3000-meter depth range, depending on the location. Similar projects have been successful in Iceland and recently at the Peppermill Resort Spa Casino in Reno, Nevada. [88] [89] Implementing a district heating approach could allow several buildings to benefit from a shared capital investment, promoting cost-effectiveness and sustainable use of geothermal energy for heating across diverse urban structures.

88 Ragnarsson, Árni, Benedikt Steingrímsson, and Sverrir Thorhallsson. 2021. *"Geothermal Development in Iceland 2015–2019"* (PDF). *Proceedings World Geothermal Congress 2020+1,* https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2020/01063.pdf.

89 Peppermill Reno. Press release. *"Geothermal Energy Powers The Peppermill Headlining the Resort Hotel's Vast Green Initiatives,"* https://www.peppermillreno.com/about-us/press-room/press-releases/peppermill-green-initiatives/.

Table 2: FY 2024–2025 Gas R&D Plan Equity Framework Matrix

#	R&D Topic	Health and Safety	Access and Education	Financial Benefits	Economic Development
1	Gas Decommissioning	Indirect Benefits	Indirect Benefits	Indirect Benefits	Indirect Benefits
2	Gas System Safety	Direct Benefits	Indirect Benefits	Indirect Benefits	Indirect Benefits
3	Renewable Generation	Direct Benefits	Direct Benefits	Indirect Benefits	Direct Benefits
4	Building Decarbonization	Direct Benefits	Indirect Benefit	Indirect Benefits	Indirect Benefit

Source: California Energy Commission

Next Steps

Upon review and approval of the Gas R&D Budget Plan by the CPUC, CEC staff will begin conducting additional research scoping, which may include hosting public workshops to further develop these initiatives into competitive grant solicitations.[90] A public preapplication workshop will be held for each solicitation to discuss and clarify the purpose, eligibility, project requirements, and scoring criteria with potential applicants. Selected projects will be presented for approval at CEC business meetings. Project summaries are maintained on CEC's Energize Innovation website, and final reports for completed projects are published on CEC's publication website.[91] [92]

90 California Energy Commission. *"Solicitations,"* https://www.energy.ca.gov/funding-opportunities/solicitations.

91 Energize Innovation. California Energy Commission. *"Project Showcase,"* https://www.energizeinnovation.fund/projects.

92 California Energy Commission. *"Energy Commission Publications,"* https://www.energy.ca.gov/resources/publications/energy-commission-publications.

LIST OF ACRONYMS

Acronym	Spelled-Out Terms
AB	Assembly Bill
ARCHES	Alliance for Renewable Clean Hydrogen Energy Systems
ARPA-E	Advanced Research Projects Agency–Energy
CalGEM	California Geologic Energy Management Division
CALSEED	California Sustainable Energy Entrepreneur Development
CARB	California Air Resources Board
CEC	California Energy Commission
CO	Carbon monoxide
COVID	Coronavirus disease
CCA	Community choice aggregator
CPUC	California Public Utilities Commission
DACAG	Disadvantaged Communities Advisory Group
DOE	U.S. Department of Energy
Energy Code	Building Energy Efficiency Standards – Title 24
EPIC	Electric Program Investment Charge
ERDD	Energy Research and Development Division
FOA	Funding opportunity announcements
FY	Fiscal year
Gas Decarb OIIP	CEC's Gas Decarbonization Order to Institute Informational Proceeding
Gas R&D	Gas research and development
GFO	Grant funding opportunity
GHG	Greenhouse gas
GO-Biz	The Governor's Office of Business and Economic Development
IEPR	Integrated Energy Policy Report
IOU	Investor-owned utility
JAEDI	Justice Access Equity Diversity Inclusion

Acronym	Spelled-Out Terms
LADWP	Los Angeles Department of Water and Power
LGBTQ	Lesbian, gay, bisexual, transgender, and queer
LNG	Liquified natural gas
Long-Term Gas Research Strategy	Long-Term Technological Research and Development Strategy to Meet Aggressive Statewide Decarbonization Goals
NOx	Oxides of nitrogen
PHMSA	Pipeline and Hazardous Materials Safety Administration
PICG	Policy and Innovation Coordination Group
PIER	Public Interest Energy Research
PG&E	Pacific Gas and Electric
POU	Publicly owned utility
R&D	Research and development
R&D Program	Public Interest Research, Development, and Demonstration Program
SB	Senate Bill
SDG&E	San Diego Gas & Electric
SoCalGas	Southern California Gas Company
TAC(s)	Technical Advisory Committee/Committees
US DOT	United States Department of Transportation

GLOSSARY

For additional information on commonly used energy terminology, see the following industry glossary links:

- California Air Resources Board Glossary, available at https://ww2.arb.ca.gov/about/glossary
- California Energy Commission Energy Glossary, available at https://www.energy.ca.gov/resources/energy-glossary
- California Public Utilities Commission Glossary of Acronyms and Other Frequently Used Terms, available at https://www.cpuc.ca.gov/glossary/

Carbon capture utilization and storage: The process of capturing carbon dioxide, either from a concentrated stream or from the atmosphere, then containing it for further use or storage.

Carbon dioxide (CO2): A naturally occurring gas, CO_2, also referred to as carbon, is also a by-product of burning fossil fuels (such as oil, gas, and coal), burning biomass, land-use changes, and industrial processes (for example, cement production). It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a global warming potential of 1.

Carbon neutrality: Carbon dioxide and other GHG emissions generated by sources such as transportation, power plants, and industrial processes must be less than or equal to the amount of carbon dioxide that is stored, both in natural sinks such as forests and mechanical sequestration such as carbon capture and sequestration. Executive Order B-55-18 established a target for California to achieve carbon neutrality by 2045 and maintain net negative emissions thereafter. For more information, see the CARB Carbon Neutrality web page.

Climate: Climate is the average course or condition of the weather at a place, usually over a period of years, as exhibited by temperature, wind velocity, and precipitation. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate change: Climate change refers to a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean or variability (or both) of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic (human-induced) changes in the composition of the atmosphere or in land use. Anthropogenic climate change is defined by the human impact on Earth's climate, while natural climate changes are the natural climate cycles that have been and continue to occur throughout Earth's history. Anthropogenic climate change is directly linked to the amount of fossil fuel burning, aerosol releases, and land alteration from agriculture and deforestation.

Decarbonization: The process by which countries, individuals, or other entities aim to reduce or achieve zero fossil carbon emissions. This typically refers to a reduction of the carbon emissions associated with electricity, industry, and transport. Decarbonization involves increasing the share of no- or low-carbon energy sources (renewables such as solar and wind) and decreasing the use of fossil fuels.

Demand flexibility is the ability of customers to reduce or increase load in response to grid conditions, usually through a proxy price signal or system operator or utility signal and facilitated by automation.

Disadvantaged community: Disadvantaged communities refer to the areas throughout California that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease. One way that the state identifies these areas is by collecting and analyzing information from communities all over the state. CalEnviroScreen, an analytical tool created by the California Environmental Protection Agency, combines different types of census tract-specific information into a score to determine which communities are the most burdened or "disadvantaged." For more information, see the California Office of Environmental Health Hazard Assessment's CalEnviroScreen Web page.

Disadvantaged Communities Advisory Group (DACAG): The Clean Energy and Pollution Reduction Act of 2015 (also known as Senate Bill [SB] 350) called upon the CPUC to help improve air quality and economic conditions in disadvantaged communities by, for example, changing the way the state plans the development and future operations of power plants, and rethinking the location of clean energy technologies to benefit burdened communities. In addition, SB 350 required the CPUC and the CEC to create a group representing disadvantaged communities to advise the agencies in understanding how energy programs impact these communities and could be improved to benefit these communities. For more information, see the CEC and CPUC DACAG web pages.[93]

Distributed energy resource(s) (DER): Distributed energy resources are any resource with a first point of interconnection of a utility distribution company or metered subsystem.

Distributed energy resources include:

- Demand response, which has the potential to be used as a low-GHG, low cost, price-responsive option to help integrate renewable energy and provide grid stabilizing services, especially when several distributed energy resources are used in combination and opportunities to earn income make the investment worthwhile.
- Distributed renewable energy generation, primarily rooftop photovoltaic energy systems.

93 California Energy Commission DACAG, https://www.energy.ca.gov/about/campaigns/equity-and-diversity/disadvantaged-communities-advisory-group.

- Vehicle-grid integration, or all the ways plug-in electric vehicles can provide services to the grid, including coordinating the timing of vehicle charging with grid conditions.
- Energy storage in the electric power sector to capture electricity or heat for use later to help manage fluctuations in supply and demand.

Electric Program Investment Charge (EPIC): The CEC's EPIC invests in scientific and technological research to accelerate the transformation of the electricity sector to meet the state's energy and climate goals. Investments of about $150 million annually support research and development in renewable energy, energy storage, electric system resilience, and electric technologies for buildings, businesses, and transportation. For more information, see the CEC EPIC web page and the CPUC Energy Research, Development, and Deployment web page.

End use: Final applications for which energy is ultimately used, such as heating, power generation, or transportation or a combination.

Energy efficiency: Energy efficiency means adapting technology to meet consumer needs while using less energy. The CEC adopts energy efficiency standards for appliances and buildings, which reduces air pollution and saves consumers money. The CPUC regulates ratepayer-funded energy efficiency programs and works with the investor-owned utilities, other program administrators, and vendors to develop programs and measures to transform technology markets within California using ratepayer funds. For more information, see the CEC Energy Efficiency web page and the CPUC Energy Efficiency web page.

Equity (energy equity): Energy equity is the principle of fairness in burden sharing and is a basis for understanding how the impacts and responses to climate change, including costs and benefits, are distributed in and by society in more or less equal ways. It is often aligned with ideas of equality, fairness, and justice and applied with respect to equity in the responsibility for, and distribution of, climate impacts and policies across society, generations, and gender, and in the sense of who participates and controls the processes of decision-making.

Gas end uses: Final applications of gas for energy use, such as heating, power generation, or transportation, or a combination.

Greenhouse gas (GHG): GHGs are those gaseous constituents of the atmosphere, natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapor, carbon dioxide, nitrous oxide, methane, and ozone are the primary GHGs in the Earth's atmosphere. Moreover, there several entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside carbon dioxide, nitrous oxide, and methane, the Kyoto Protocol deals with the GHGs sulfur hexafluoride, HFCs, and perfluorocarbons. In response to Assembly Bill 32 (California Global Warming Solutions Act of 2006), the definition of GHGs defined in Health and Safety Code Section 38505 includes nitrogen trifluoride in addition to those defined under the Montreal and Kyoto Protocols.

Investor-owned utility (IOU): Investor-owned utilities (IOUs) provide transmission and distribution services to all electric customers in their service territory. The utilities also provide generation service for "bundled" customers, while "unbundled" customers receive electric

generation service from an alternate provider, such as a community choice aggregator (CCA). California has three large IOUs offering electricity service: Pacific Gas and Electric, Southern California Edison, and San Diego Gas & Electric.

Low-income communities: refers to communities within California census tracts with median household incomes at or below either of the following levels: 1) 80 percent of the statewide median income or 2) the applicable low-income threshold listed in the state income limits updated by the Department of Housing and Community Development and filed with the Office of Administrative Law pursuant to subdivision (c) of Section 50093 of the Health and Safety Code.

Methane: Methane, also known as CH_4, is one of the six GHGs to be mitigated under the Kyoto Protocol and is the major component of natural gas. Emissions also occur as a result of dairy and livestock operations and disposal of organics in landfills, and the management of these organics represents a major mitigation option. Methane is a short-lived climate pollutant. Unlike carbon dioxide, which lasts for about 100 years in the atmosphere, reductions of methane can create a relatively quick reduction in global warming.

Sustainability: A dynamic process that guarantees the persistence of natural and human systems equitably.

Utility: An organization supplying the community with electricity, gas, water, or sewerage.

APPENDICES: A-G

- Appendix A: Policies Supported by FY 2024-25 Gas R&D Program Initiative Themes
- Appendix B: CPUC Resolution G-3584 Funding Encumbrance — Unspent Funds
- Appendix C: Public Comment and CEC Responses
- Appendix D: List of 2022 Gas R&D Events
- Appendix E: FY 2024-2025 Gas R&D Plan Equity Framework Topic Definitions
- Appendix F: Estimated Administration Costs
- Appendix G: Gas R&D Stakeholders Workshop Presentation

APPENDIX A:
Policies Supported by FY 2024-25 Gas R&D Program Initiative Themes

Policies Supported by Gas System Decommissioning Theme

- CPUC Rulemaking 20-01-007[94] 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 outlines strategies and guidance for climate change adaptation.
- Assembly Bill 3232 (Friedman, Chapter 373, Statutes of 2018) directed CEC to develop a *California Building Decarbonization Assessment* (2021), which provides a framework to tackle the challenges in developing a path toward reducing greenhouse gas emissions associated with California's buildings.
- The *Final 2021 Integrated Energy Policy Report Volume III: Decarbonizing the State's Gas System* (Chapter 6) outlines factors affecting the reduction or retirement of gas assets and the need for long-term gas planning, including a comprehensive assessment of the overall needs of the gas system within the long-term context of climate goals as well as with respect to weather impacts of climate change.
- 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.

94 https://www.cpuc.ca.gov/industries-and-topics/natural-gas/long-term-gas-planning-rulemaking.

Policies Supported by Gas System Safety Theme

- Senate Bill 887 (Pavley, Chapter 673, Statutes of 2016) requires the operator of a gas storage well, before January 1, 2018, to have commenced a mechanical integrity testing regime specified by the Division of Oil, Gas, and Geothermal Resources in the California's Department of Conservation and would require the division to promulgate regulations that establish standards for all gas storage wells. It also requires the division to determine by regulation what constitutes a reportable leak from a gas storage well and the timeframe for reporting those leaks, as specified.
- Senate Bill 1371 (Leno, Chapter 525, Statutes of 2014) requires reporting and mitigation of emissions from CPUC-regulated gas pipeline facilities. The bill requires gas corporations to file a report summarizing utility leak management practices, a list of new gas leaks by grade, a list of open leaks that are being monitored or are scheduled to be repaired, and a best estimate of gas loss due to leaks.
- Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) sets targets for statewide reductions in short-lived climate pollutant emissions, including a reduction in methane emissions by 40 percent below 2013 levels by 2030.
- Assembly Bill No. 1496, Chapter 604, Section 39731 (Thurmond, 2015) requires CARB to undertake monitoring and measurements of high emission methane "hot spots," life-cycle greenhouse gas emissions analysis of gas produced and imported into California, and review and assess the atmospheric reactivity of methane as a precursor to the formation of photochemical oxidant.

Policies Supported by Renewable Generation Theme

- Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) requires reductions in statewide emissions of methane by 40 percent, hydrofluorocarbon gases by 40 percent, and anthropogenic black carbon by 50 percent below 2013 levels by 2030.
- Senate Bill 100 (De León, Chapter 312, Statutes of 2018) requires 60 percent of retail sales of electricity be generated from eligible renewable energy resources by 2030 and all retail sales of electricity be renewable or zero-carbon by 2045.
- Senate Bill 1369 (Skinner, Chapter 567, Statues of 2018) requires the consideration of green electrolytic hydrogen as a form of energy storage and of other potential uses of green electrolytic hydrogen.
- Senate Bill 1075 (Skinner, Chapter 363, Statutes of 2022) mandates that a comprehensive report on hydrogen be posted to CARB's website by June 1, 2024, to include specified information on the deployment, development, and use of hydrogen

across all sectors as a key part of achieving California's climate, air quality, and energy goals.

- Assembly Bill 205 (Ting, Chapter 61, Statues of 2022) created the Strategic Reliability Reserve to support the state's electric grid reliability and required the CEC to implement and administer the Distributed Electricity Backup Assets Program to incentivize the construction of cleaner and more efficient distributed energy assets.
- Environmental & Social Justice Action Plan Version 2.0 by the California Public Utilities Commission establishes both a commitment to furthering principles of environmental and social justice and an operating framework with which to integrate environmental and social justice considerations throughout the agency's work.
- 2022 Scoping Plan for Achieving Carbon Neutrality by the California Air Resources Board lays out a plan to achieve carbon neutrality by 2045 and identifies renewable hydrogen produced through electrolysis or from biomethane as an alternative to fossil fuels in the transportation, buildings, industry, and electricity sectors.
- CPUC Rulemaking Decision 22-02-025 February 24, 2022: Implementation of Senate Bill 1440. This decision establishes a biomethane procurement program for California's four large gas utilities that is designed to help achieve the state's short-lived climate pollutant (SLCP) goals, which call for a 40 percent reduction in methane and other SLCPs by 2030.
- CPUC Rulemaking Decision 22-12-057 December 15, 2022: This decision directs California's four large gas utilities to propose system testing on the effects of hydrogen blended into methane at concentrations ranging from 0.1 percent to 20 percent. It further establishes safety thresholds for hydrogen content in biomethane and makes modifications to existing biomethane-related reporting requirements.

Policies Supported by Building Decarbonization Theme

- Assembly Bill 3232 (Friedman, Chapter 373, Statutes of 2018) directed CEC to develop a *California Building Decarbonization Assessment* (2021), which provides a framework to tackle the challenges in developing a path toward reducing greenhouse gas emissions associated with California's buildings.
- Integrated Energy Policy Report (IEPR) Volume 1: Building Decarbonization (2021) includes recommendations to accelerate decarbonization of buildings in California.
- Senate Bill 1112 (Becker, Chapter 834, Statutes of 2022) requires the CEC, on or before December 31, 2023, to prepare and submit a report that describes any statutory changes necessary to improve access to federal funding for financing or investment solutions to provide zero-emission, clean energy, or decarbonizing building upgrades.

- California Energy Code is a component of the California Building Standards Code, updated every three years through the collaborative efforts of state agencies including the California Building Standards Commission and the CEC. The Code ensures that new and existing buildings achieve energy efficiency and preserve outdoor and indoor environmental quality through use of the most energy efficient technologies and construction.
- Senate Bill (SB) 1477, Low-emissions Buildings and Sources of Heat Energy, requires the CPUC to develop, in consultation with the CEC, two programs (Building Initiative for Low-Emissions Development and Technology and Equipment for Clean Heating) aimed at reducing greenhouse gas emissions associated with buildings.

APPENDIX B:
CPUC Resolution G-3484 Funding Encumbrance – Unspent Funds

Per the CPUC's request in Resolution G-3592 and consistent with Resolution G-3484, Appendix B shows the research funds from FY 2014–15 to FY 2023-24 Gas R&D Program budget plans ***encumbered and unspent as of June 30, 2023***. Each budget plan approved by CPUC describes estimated allocations of funding among the Gas R&D research areas.

The CEC's Gas R&D program budget process allocates funding to CPUC-approved research areas/initiatives that are subsequently acted upon by developing specific projects selected through competitive solicitations. Encumbered funds refer to funds that are committed to a specific project that has been approved at a Business Meeting and for which the agreement package has been executed (signed by both parties). Funds Unspent refers to funds that have not been encumbered to an executed agreement (contract or grant), or previously encumbered funds that become unencumbered because the agreement has been canceled or due to other reasons. Following 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.

Proposed FY 2023-24 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2023-24 Budget Plan	Total FY 2023-24 Funds Encumbered	Total FY 2023-24 Funds Unspent*
Gas Leakage Mitigation	$6.00	$0.00	$6.00
Building Decarbonization	$7.00	$0.00	$7.00
Targeted Gas System Decommissioning	$2.00	$0.00	$2.00
Leveraging Cost Share Opportunities	$5.64	$0.00	$5.64
Comprehensive Programmatic Evaluation, Under G-3592	$.960	$0.00	$.960
TOTAL	**$21.60**	**$0**	**$21.60**

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

Source: California Energy Commission

**FY 2023-24 Gas R&D Budget Plan was submitted to the CPUC on June 1, 2023, and is pending approval.*

Proposed FY 2023-24 Gas R&D Supplemental Budget Plan Funds Encumbered as of June 30, 2023

Research Area	Total FY 2023-24 Budget Plan	Total FY 2023-24 Funds Encumbered	Total FY 2023-24 Funds Unspent*
Gas Leakage Mitigation	$4.13	$0.00	$4.13
Building Decarbonization	$0.00	$0.00	$0.00
Targeted Gas System Decommissioning	$0.00	$0.00	$0.00
Leveraging Cost Share Opportunities	$2.41	$0.00	$2.41
Comprehensive Programmatic Evaluation, Under G-3592	$0.00	$0.00	$0.00
TOTAL	**$6.54**	**$0**	**$6.54**

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

Source: California Energy Commission

**FY 2023-24 Gas R&D Budget Plan was submitted to the CPUC on June 1, 2023, and is pending approval.*

FY 2022-23 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2022-23 Approved Budget Plan	FY 2022-23 Current Budget Plan	Total FY 2022-23 Funds Encumbered	Total FY 2022-23 Funds Unspent	Actual or Anticipated Solicitation Release or Encumbrance*
Targeted Gas System Decommissioning	$3.50	$4.10	$0	$4.10	$700,000 Anticipated to be Released Fiscal Year (FY) Q4 2023 $3.4M Anticipated Solicitation to be Released FY Q2 2024
Decarbonization of Gas End Uses	$13.00	$13.00	$0	$13.00	$3.6M (GFO-22-504) Funds Encumbered January 2024 *Unspent Funds for an Anticipated Supplemental Plan $913,632* $4.5M (GFO-22-502) Funds Encumbered October 2023 $3M Anticipated Solicitation to be Released in FY Q3 2024 $1M Anticipated Solicitation to be Released in FY 2024
Energy Efficiency	$1.50	$1.50	$0	$1.50	$1.5M Anticipated Solicitation to be Released FY Q1 2024
Gas Pipeline Safety and Integrity	$0	$3.00	$0	$3.00	$2.99M (GFO-22-503) Funds Encumbered January 2024 *Unspent Funds for an Anticipated Supplemental Plan $7,772*
Entrepreneur Development	$3.60	$0.00	$0	$0.00	$3.6M funds reallocated resulting in a $0 balance per CPUC Resolution 3592*
TOTAL	**$21.60**	**$21.60**	**$0**	**$21.60**	

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

Source: California Energy Commission

**FY 2022-23 Gas R&D Budget Plan, approved March 16, 2023, in part, by CPUC Resolution G-3592. CPUC modified the $3.6 million budget for Entrepreneur Development (CalSEED Initiative) and directed the CEC to submit a new proposal for reallocating the $3.6 million via a Tier 2 Advice Letter. CPUC approved CEC's request to reallocate $600,000 to Targeted Gas System Decommissioning and $3,000,000 to Gas Pipeline Safety and Integrity.*

FY 2021-22 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2021-22 Approved Budget Plan	FY 2021-22 Current Budget Plan	Total FY 2021-22 Funds Encumbered	Total FY 2021-22 Funds Unspent	Actual or Anticipated Solicitation Release or Encumbrance
Energy Efficiency	$6.10	$6.10	$0	$6.10	$6.1M (GFO-23-503) Anticipated Encumbrance FY Q2 2024
Renewable Energy and AdvancedGeneration	$4.00	$4.00	$0	$4.00	$4M (GFO-22-504) Funds Encumbered January 2024
Gas Infrastructure Safety and Integrity	$4.00	$4.00	$0	$4.00	$4M (GFO-22-503) Funds Encumbered August 2023 and January 2024
Energy-Related EnvironmentalResearch	$3.50	$3.50	$0	$3.50	$2M (GFO-23-501) Anticipated Encumbrance FY Q4 2024 $1.5M Anticipated Solicitation to be Released in FY Q4 2024
Transportation	$4.00	$4.00	$0	$4.00	$4M (GFO-22-502) Funds Encumbered October 2023
TOTAL	**$21.60**	**$21.60**	**$0**	**$21.60**	

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

Source: California Energy Commission

FY 2020-21 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2020-21 Approved Budget Plan	FY 2020-21 Current Budget Plan	Total FY 2020-21 Funds Encumbered	Total FY 2020-21 Funds Unspent
Energy Efficiency*	$3.00	$3.00	$1.77	$1.23
Renewable Energy and Advanced Generation	$4.00	$4.00	$4.00	$0
Gas Infrastructure Safety and Integrity	$9.10	$9.10	$9.10	$0
Energy-Related Environmental Research	$1.50	$1.50	$1.50	$0
Transportation	$4.00	$4.00	$4.00	$0
TOTAL	**$21.60**	**$21.60**	**$20.37**	**$1.23**

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

Source: California Energy Commission

**Energy Efficiency: The remaining $1.23m of encumbered funds was included in the Proposed FY 2023-24 Gas R&D Supplemental Budget Plan – Leveraging Cost Share Opportunities.*

FY 2019-20 Gas R&D Supplemental Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2019-20 Approved Supplemental Budget Plan	CPUC FY 2019-20 Supplemental Current Budget Plan	CPUC FY 2019-20 Supplemental Funds Encumbered	CPUC FY 2019-20 Supplemental Funds Unspent	Actual or Anticipated Solicitation Release or Encumbrance
Energy Efficiency	$1.00	$1.00	$0	$1.00	$1M (GFO-22-501) Funds Encumbered July 2023
Renewable Energy and Advanced Generation	$0	$0	$0	$0	
Gas Infrastructure Safety and Integrity	$2.00	$2.00	$2.00	$0	
Energy-Related Environmental Research	$2.00	$2.00	$2.00	$0	
Transportation	$0	$0	$0	$0	
Gas Small Grant Program	$2.29	$2.29	$2.29	$0	*As of FY2023-24 (subsequent to the reporting period end date for this table of June 30, 2023), additional Unspent Funds for an Anticipated Supplemental Plan $2.29M*
TOTAL	**$7.29**	**$7.29**	**$6.29**	**$1.00**	

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

Source: California Energy Commission

FY 2019-20 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2019-20 Approved Budget Plan	FY 2019-20 Current Budget Plan	Total FY 2019-20 Funds Encumbered	Total FY 2019-20 Funds Unspent
Energy Efficiency*	$9.00	$9.63	$7.99	$1.64
Renewable Energyand Advanced Generation	$3.00	$2.89	$2.89	$0
Gas Infrastructure Safety and Integrity*	$2.00	$1.58	$1.58	$0
Transportation*	$6.60	$6.50	$6.50	$0
Gas Strategic Plan (Cross-Cutting)	$1.00	$1.00	$1.00	$0
TOTAL	**$21.60**	**$21.60**	**$19.96**	**$1.64**

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

Source: California Energy Commission

**Energy Efficiency: $1.64m unspent funds have been committed to solicitation GFO-22-501; CEC executedagreements and encumbered funds in July 2023.*

**The CEC reallocated $630,000 from the Renewable Energy and Advanced Generation, Gas Infrastructure Safety and Integrity and Transportation research areas to Energy Efficiency due to strong proposals in high-priority research areas.*

FY 2018-19 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2018-19 Approved Budget Plan	FY 2018-19 Current Budget Plan	Total FY 2018-19 Funds Encumbered	Total FY 2018-19 Funds Unspent
Energy Efficiency	$6.00	$9.32	$9.32	$0
Renewable Energyand Advanced Generation*	$3.00	$0	$0	$0
Gas Infrastructure Safety and Integrity	$5.60	$5.60	$5.60	$0
Energy-Related Environmental Research	$3.00	$4.36	$4.36	$0
Transportation*	$4.00	$2.31	$2.31	$0
TOTAL	**$21.60**	**$21.60**	**$21.60**	**$0**

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

Source: California Energy Commission

**The CEC reallocated $3.32m from the Renewable Energy and Advanced Generation and Transportation research areas to Energy Efficiency due to strong proposals in high-priority research areas.*

**The CEC reallocated $1.36m from the Renewable Energy and Advanced Generation research area to Energy-Related Environmental Research due to strong proposals in high-priority research areas.*

FY 2017-18 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2017-18 Approved Budget Plan	FY 2017-18 Current Budget Plan	Total FY 2017-18 Funds Encumbered	Total FY 2017-18 Funds Unspent**	Actual or Anticipated Solicitation Release or Encumbrance
Energy Efficiency*	$6.60	$4.57	$4.57	$0	
Renewable Energyand Advanced Generation	$4.00	$4.00	$4.00	$0	
Gas Infrastructure Safety and Integrity	$5.00	$5.82	$5.82	$0	
Energy-Related Environmental Research	$3.00	$3.46	$3.46	$0	
Transportation	$3.00	3.75	$2.89	$.87	*Unspent Funds for an Anticipated Supplemental Plan $865,642*
TOTAL	**$21.60**	**$21.60**	**$20.73**	**$.87**	

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

Source: California Energy Commission

**The CEC reallocated $2.03m from Energy Efficiency to Gas Infrastructure Safety and Integrity, Transportation, Energy-Related Environmental Research areas due to strong proposals in high-priority research areas.*

***Transportation: as of June 30, 2022, unspent funds $.87m from terminated projects will be included in a future Proposed Gas R&D Supplemental Budget Plan – Gas Leakage Mitigation.*

FY 2016-17 Gas R&D Supplemental Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2016-17 Supplemental Approved Budget Plan	FY 2016-17 Supplemental Current Budget Plan	Total FY 2016-17 Supplemental Funds Encumbered	Total FY 2016-17 Supplemental Funds Unspent
Energy Efficiency*	$.91	$0	$0	$0
Renewable Energy andAdvanced Generation	$0	$0	$0	$0
Gas Infrastructure Safety and Integrity	$1.70	$2.61	$2.61	$0
Energy-Related Environmental Research	$2.70	$2.70	$2.70	$0
Transportation	$0	$0	$0	$0
TOTAL	**$5.31**	**$5.31**	**$5.31**	**$0**

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

Source: California Energy Commission

**The CEC reallocated $.91m from Energy Efficiency to Gas Infrastructure Safety and Integrity research area due to strong proposals in high-priority research areas.*

FY 2016-17 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2016-17 Approved Budget Plan	FY 2016-17 Current Budget Plan	Total FY 2016-17 Funds Encumbered	Total FY 2016-17 Funds Unspent	Actual or Anticipated Solicitation Release or Encumbrance
Energy Efficiency	$7.10	$5.20	$4.03	$1.18	$1.18M Included in FY 2023-2024 Supplemental Budget Plan *As of FY2023-24 (subsequent to the reporting period end date for this table of June 30, 2023), additional unspent funds for an Anticipated Supplemental Plan $543,673.*
Renewable Energyand Advanced Generation	$4.40	$5.02	$5.02		
Gas Infrastructure Safety and Integrity	$4.00	$3.87	$3.87		
Energy-Related Environmental Research	$2.60	$2.69	$2.69		
Transportation	$3.50	$4.82	$2.19	$2.63	$2.63M Included in FY 2023-2024 Supplemental Budget Plan
TOTAL	**$21.60**	**$21.60**	**$17.79**	**$3.81**	

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

Source: California Energy Commission

FY 2015-16 Gas R&D Supplemental Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2015-16 Supplemental Approved Budget Plan	FY 2015-16 Supplemental Current Budget Plan	Total FY 2015-16 Supplemental Funds Encumbered*	Total FY 2015-16 Supplemental Funds Unspent
Energy Efficiency	$0	$0	$0	$0
Renewable Energy andAdvanced Generation	$0	$0	$0	$0
Gas Infrastructure Safety and Integrity	$1.50	$1.50	$1.50	$0
Energy-Related Environmental Research	$2.10	$2.10	$2.10	$0
Transportation	$0	$0	$0	$0
TOTAL	**$3.60**	**$3.60**	**$3.60**	**$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 funded high-priority research areas when strong research proposals were received.*

FY 2015-16 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2015-16 Approved Budget Plan	FY 2015-16 Current Budget Plan	Total FY 2015-16 Funds Encumbered	Total FY 2015-16 Funds Unspent	Actual or Anticipated Solicitation Release or Encumbrance
Energy Efficiency	$7.10	$7.10	$7.10	$0	
Renewable Energy and Advanced Generation	$5.80	$5.80	$4.62	$1.18	$1.18M included in FY 2019-2020 Supplemental Budget Plan
Gas Infrastructure Safety and Integrity	$1.00	$1.00	$1.00	$0	
Energy-Related Environmental Research	$3.30	$3.30	$3.30	$0	
Transportation	$4.40	$4.40	$2.90	$1.50	$1.5M included in FY 2023-2024 Supplemental Budget Plan
TOTAL	**$21.60**	**$21.60**	**$18.91**	**$2.68**	

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

Source: California Energy Commission

FY 2014-15 Gas R&D Budget Plan Funds Encumbered as of June 30, 2023

Research Area	CPUC FY 2014-15 Approved Budget Plan	FY 2014-15 Current Budget Plan	Total FY 2014-15 Funds Encumbered	Total FY 2014-15 Funds Unspent
Energy Efficiency*	$8.60	$7.48	$7.48	$0
Renewable Energy andAdvanced Generation	$3.50	$2.48	$2.48	$0
Gas Infrastructure Safety and Integrity	$2.50	$4.68	$4.68	$0
Energy-Related Environmental Research	$3.00	$3.62	$3.62	$0
Transportation*	$4.00	$3.34	$3.34	$0
TOTAL	**$21.60**	**$21.60**	**$21.60**	**$0**

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

Source: California Energy Commission

**The CEC reallocated $2.18m from Energy Efficiency and Renewable Energy and Advanced Generation research areas to Gas Infrastructure Safety and Integrity research area due to strong proposals in high-priority research areas.*

**The CEC reallocated $.62m from Transportation and Renewable Energy and Advanced Generation research areas to Energy-Related Environmental research area due to strong proposals in high-priority research areas.*

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, the coordination meeting with California Public Utilities Commission (CPUC) staff, and meeting with the Disadvantaged Communities Advisory Group (DACAG) representatives on proposed initiatives for the fiscal year (FY) 2024-25 Gas Research and Development (Gas R&D) Program Budget Plan. The stakeholder engagement events to support the development of this Budget Plan included the following:

- On November 15, 2023, CEC staff held coordination meetings with CPUC staff.
- On December 7, 2023, CEC staff presented the proposed budget plan to CPUC Commissioner Douglas. Comments were not directed to the initiatives and therefore are not summarized below.
- On December 15, 2023, CEC staff held a public workshop and invited written public comments on the proposed research initiatives.
- On January 19, 2024, CEC staff met the full DACAG to present the proposed budget plan.

Based on feedback received through this process and current funding priorities, CEC staff did not include the proposed initiative on Clean Renewable Hydrogen Distribution: Hydrogen Separation in the FY 2024-25 Gas R&D Program Budget Plan and redirected the associated funds. For a summary of this proposed initiative, please see Appendix D.

A summary of the comments provided and CEC staff responses for each are provided in the following sections:

CPUC Staff Coordination Meeting Comment Summary and CEC Responses

The CEC presented the proposed FY 2024-25 Gas R&D Program Budget Plan to representatives of the CPUC's Energy Division and Safety and Enforcement Division at a meeting on Nov 15, 2023. At the meeting, CEC staff presented five proposed initiatives for the FY 2024-2025 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.

Gas Decommissioning: Support Equitable, Safe, and Cost-Effective Decarbonization of California's Gas System

- CPUC staff commented that equipment replacement experiences under local fossil gas bans could provide useful empirical information about potential problems and opportunities for improvement in electrification processes.
    - CEC staff agreed and provided information on jurisdictions within the state that had adopted building codes aimed at reducing reliance on gas.
- CPUC staff commented that Berkeley's gas ban had been overturned.

- CEC staff provided several references on legal decisions related to gas bans in the state, namely concerning the ruling of the United States Court of Appeals for the Ninth Circuit that the City of Berkeley could not regulate the quantity of gas used.

- CPUC staff requested clarification on the schedule and process for gas decommissioning research, particularly how it aligns with decommissioning pilot research in northern and southern California under CEC grants to Energy + Environmental Economics, Inc. (E3) and RAND, respectively.
  - CEC staff outlined two overarching visions: one addressing the schedule and perspective for research that has been proposed in the draft initiative, and the other focusing on translating research findings from the aforementioned decommissioning pilot grants into actual pilot implementation. Regarding the latter, decisions on how to proceed should stem from findings of the two projects, including assessment by the CEC grant managers, as well as from potential funding availability and opportunities for collaboration with gas investor-owned utilities (IOUs).

Gas System Safety: Innovations for Cost-Effective Operation & Maintenance of Critical Infrastructure During the Gas Transition

- CPUC staff highlighted the significant expenses associated with adhering to California Department of Conservation Geologic Energy Management Division (CalGEM) testing regulations and a desire to streamline these tests, making them less time-consuming, costly, and intrusive.
  - CEC staff emphasized that this initiative would advance technologies and methods, including continuous monitoring, non-intrusive inspection, and non-destructive testing, to lower the costs of maintaining the safety, integrity, and reliability of gas storage facilities and transmission pipelines.

- CPUC staff sought clarification on how continuous monitoring and non-intrusive inspection technologies would influence decisions regarding derating and decommissioning.
  - CEC staff highlighted that the decision to decommission a pipeline depends on its condition and usage. If a pipeline is in poor condition and not used, decommissioning may be appropriate. Conversely, if a pipeline is actively used but in poor health, repair may be warranted. Access to continuous and detailed data on usage, conditions, and degradation trends of gas infrastructure can significantly aid in making these decisions. CEC has previously supported initiatives using fiber optic sensors for continuous monitoring of underground gas storage wells and intends to expand these efforts.

- CPUC staff inquired about the publication status of the study conducted by Southern California Gas Company (SoCalGas) as part of its methane leak abatement plan with Lawrence Berkeley National Lab and CEC.

- CEC staff indicated that the final report for this study is still awaiting publication. The project is anticipated to conclude by mid-2024, with the final report expected to be published around that time.

- CPUC staff requested an explanation of how non-intrusive well inspections could lower costs to ratepayers by avoiding the expenses associated with intrusive inspections and subsequent reductions in system capacity.
  - CEC staff outlined that current storage well inspection procedures necessitate shutting down wells for inspection, rendering them unusable for gas injection or withdrawal during that period. Consequently, maintaining capacity requires additional wells. Moreover, capacity reductions resulting from inspections might prolong the service life of older wells or necessitate the creation of new ones. Non-intrusive testing, however, would mitigate operational disruptions, minimize storage well downtime, and diminish the necessity for extra wells. This approach effectively reduces both equipment and operation and maintenance costs.
- CPUC staff requested an explanation of how non-intrusive well inspections can avoid safety risks compared to intrusive well inspections.
  - CEC staff responded that conventional well inspections require opening the well, inserting instruments, and removing large components for inspection, all of which pose risks of accidental damage to the equipment. Non-intrusive methods, on the other hand, minimize the need to open wells for inspections, thereby reducing associated safety hazards. CEC clarified that this initiative is currently focused solely on transmission pipelines, excluding distribution pipelines.

Renewable Generation: Fuel-Flexible Distributed Power Generation

- CPUC sought clarification on how the prime movers fit with retrofits, specifically on developing more fuel-based power generation in light of the state's long-term policy goals to transition away from fossil fuels wherever feasible.
  - CEC staff explained that prime movers can be modified or designed to operate on a single renewable fuel or mix of renewable fuels such as biomethane, hydrogen, or ammonia. While policies like Assembly Bill 205 incentivize cleaner and more efficient distributed energy assets, they do not account for adapting these systems to evolving renewable fuel supplies, which this initiative aims to address. Furthermore, the initiative aligns with the California Air Resources Board's 2022 Scoping Plan and Senate Bill 100, which emphasize the need for an adaptable generation system to withstand decarbonization treads, policies, and increasing electric demand while eliminating fossil fuels. This initiative aims to fulfill that need by promoting the development of renewable fuel-based power generation.
- CPUC sought clarity regarding the extent to which the end target of the initiative would involve new power plants or make use of existing equipment.

- CEC staff clarified and edited the initiative title and scope to focus on distributed generation. In addition, CEC staff is considering limiting new installations to use electrochemical, thermochemical, or other proven pathways, with very low emissions even without being dependent on emissions control technologies and allowing modifications to existing combustion resources, to avoid investing in new combustion demonstrations.

- CPUC inquired about the need for public funding for this initiative, as the electric generation industry is looking at alternatives to fossil gas generation.
  - Based on literature review and prior experience with industrial grant recipients and project partners, CEC staff found industries are generally risk averse. CEC's support in continuing the development of power generation technologies can help reduce the risk. In addition, CEC staff posed the question to stakeholders, to which entities responded as summarized below, supporting the need for public funds.
- CPUC inquired about the potential to fund research to explore biomethane cost reductions.
  - CEC staff appreciate this suggestion and may consider it in a future Gas R&D initiative.

Clean Renewable Hydrogen Distribution: Hydrogen Separation

- CPUC requested clarification on the intended definition of hydrogen in the scope of the initiative.
  - CEC staff clarified that the initiative intends to align with CPUC's interim definition established for clean renewable hydrogen in D.22-15-057.[95]
- CPUC requested clarification on the range of hydrogen blend percentages that the initiative would focus on, considering D.22-15-057 ordered the Joint Gas Utilities to submit applications for hydrogen blending pilot programs to test hydrogen blends up to 20 percent by volume.
  - CEC staff clarified that the initiative intends to focus on hydrogen separation technologies that could be used with a future blended gas stream. CEC staff revised the initiative to target applicability to blends of three to 20 percent by volume.
- CPUC staff raised concerns about committing research on hydrogen separation before more foundational questions are answered regarding the costs and expected role of hydrogen blending.

95 California Public Utilities Commission. Decision D.22-12-057 - Decision Directing Biomethane Reporting and Directing Pilot Projects To Further Evaluate And Establish Pipeline Injection Standards For Clean Renewable Hydrogen. December 2022. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K055/500055657.PDF

- CEC staff responded that research on hydrogen separation can inform understanding of potential costs and mitigation strategies that could apply to a systemwide blending scenario.

Building Decarbonization: Networked Geothermal District Heating Study

- CPUC staff asked for clarity on the connection between networked geothermal district heating and its impact on gas ratepayers.
  - CEC staff highlighted that this initiative approach offers gas ratepayers a clear pathway toward decarbonization. Additionally, it presents an opportunity to leverage the skills and expertise of the existing gas workforce.
- CPUC staff sought clarification on the rationale for bypassing ground source heat pumps.
  - CEC staff clarified that typical ground source heat pumps require significant land space, and many do not achieve sufficiently high temperatures. The study is not bypassing ground source heat pumps but rather focusing on "expensive/hard to electrify building types" for which conventional ground source heat pumps may not be sufficient.

DACAG Meeting Comment Summary and CEC Responses

The CEC presented the proposed FY 2024-25 Gas R&D Program Budget Plan to representatives of the DACAG at a meeting on January 19, 2024. At the meeting, CEC staff presented an overview of the Gas R&D Program and development process and summaries of the five proposed initiatives included in the proposed FY 2024-25 Gas R&D budget plan. The CEC appreciates the helpful questions and comments from DACAG members on the proposed FY 2024-25 Gas R&D budget plan. Below is a summary of DACAG member comments and CEC staff responses organized by initiative:

Gas Decommissioning: Support Equitable, Safe, and Cost-Effective Decarbonization of California's Gas System

- No comment

Gas System Safety: Innovations for Cost-Effective Operation & Maintenance of Critical Infrastructure During the Gas Transition

- DACAG Members sought clarification regarding the development of technologies and approaches that may become inappropriate if hydrogen blending were to occur.
  - CEC staff clarified that previous funded research initiatives include projects aimed at evaluating the risks associated with hydrogen blending. Notably, a project with University of California, Los Angeles in partnership with Pacific Gas & Electric and SoCalGas is developing a quantitative risk assessment of hydrogen blending and will evaluate potential risk mitigation measures. This ongoing study is anticipated to yield valuable insights. Additionally, a recently approved FY22-23 Gas R&D Budget Plan initiative is set to investigate the

potential introduction of hydrogen to gas storage facilities, emphasizing the need for understanding special inspection or monitoring measures tailored to such systems if used to store hydrogen in the future.

- DACAG members sought clarity on exploration of gas inspection technologies, particularly focusing on inspections for hydrogen and storage, and expressed concerns regarding potential embrittlement issues.
    - CEC staff clarified that the initiative would center on improving safety and affordability of existing gas infrastructure. CPUC staff clarified that the overarching aim is to mitigate the expenses associated with maintaining the current gas system amidst escalating regulatory demands, thereby alleviating potential rate impacts.
    - CEC staff will advocate prioritizing infrastructure in disadvantaged communities during implementation and progress with testing out inspection technologies in gas system safety efforts.
- DACAG members sought clarity on whether methane emissions are included in the research initiative, suggesting a discussion on both hydrogen and fugitive methane emissions.
    - CEC staff clarified that the FY23-24 Gas R&D Budget Plan includes an initiative on this topic pending CPUC approval. CEC staff also discussed the portfolio of active Gas R&D Program projects focusing on methane emissions, particularly highlighting two efforts: 1) studying behind-the-meter methane emissions in residential settings with an emphasis on multifamily homes and 2) monitoring regional multi-tiered methane emissions associated with production, processing, and distribution in the San Joaquin Valley.

Renewable Generation: Fuel-Flexible Distributed Power Generation

- No comment

Clean Renewable Hydrogen Distribution: Hydrogen Separation

- DACAG members sought clarification on the types of gas streams being considered for hydrogen separation.
    - CEC staff clarified that hydrogen separation technology would be applicable to blended gas streams that may be present in a future gas pipeline system. CEC staff also clarified current progress in CPUC's Renewable Gas Proceeding, including forthcoming gas utility hydrogen blending pilot proposals to test blends up to 20 percent in isolated segments of the gas system. Findings from the pilots and other research will inform future policy decisions on broader deployment of hydrogen blends.
- DACAG members sought clarification on whether the hydrogen blend percentage referenced was by volume or energy.

    - CEC staff confirmed that the three to 20 percent blend is by volume. Higher hydrogen blends facilitate more efficient hydrogen recovery. Yet, this comes with trade-offs such as the need to upgrade infrastructure.
- DACAG members stated they have concerns with hydrogen blending and recommended directing hydrogen towards the hardest to decarbonize sectors of the economy like industrial feedstocks, aviation, and marine shipping.
    - As noted above, due to stakeholder concerns with hydrogen blending in pipelines, CEC decided to not include this initiative in the FY2024-2025 Gas R&D Budget Plan.

Building Decarbonization: Networked Geothermal District Heating Study

- DACAG members expressed enthusiasm for networked geothermal district heating. They emphasized the importance of exploring energy efficiency measures alongside supply-side solutions.

Public Workshop Comments and CEC Staff Responses

The CEC appreciates the thoughtful and helpful comments from stakeholders received in response to CEC's January 17, 2023, Gas R&D Workshop, where staff presented proposed initiatives for the FY 2023-24 Gas R&D Program Budget Plan. The CEC requested comments at the January 17, 2023, workshop and via notifications on the CEC website, subscription lists, 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.

Public Workshop and Written Public Comment Summary and CEC Responses

Gas Decommissioning: Support Equitable, Safe, and Cost-Effective Decarbonization of California's Gas System

- SoCalGas Comment: Suggested consideration of pipeline blending of renewable gas as an alternative decarbonization pathway.
    - CEC Response: Pipeline blending of renewable gas is anticipated to be a possible gas system decarbonization pathway that could be considered under this initiative.

Gas System Safety: Innovations for Cost-Effective Operation and Maintenance of Critical Infrastructure During the Gas Transition

- CPUC Comment: Very interested in well inspection practices that don't hamper operations of the wells to serve their purpose in mitigating price fluctuations in gas markets.
    - CEC Response: The gas system safety initiative is responsive to the challenges with meeting CalGEM regulations described in CPUC's 2023 Senate Bill 695 Report, including higher operations and maintenance costs, reduced

system capacities, and retention of older wells due to downtime caused by well inspections required at a standard two-year interval.[96] This initiative supports the development of technologies and methods for less intrusive well inspections to reduce well downtime and maintain system capacity, as well as continuous monitoring to support early detection of anomalies before they escalate into significant safety concerns. This research may also inform policies related to alternative inspection intervals by providing useful data about well integrity without requiring frequent conventional inspections.

- SoCalGas Comment: Important initiative; suggest coordination with SoCalGas; noted SoCalGas' existing pipeline inspection technology and related research.
    - CEC Response: CEC staff recognize the value of leveraging work done by SoCalGas and others in this space. Research developed and conducted under this initiative will incorporate input from IOUs relative to current practices and technologies, research needs, and challenges with pipeline inspection and material verification.

Renewable Generation: Fuel-Flexible Distributed Power Generation

Public Workshop Comments Received:

- CPUC Staff Comment: Interested in applications for utilizing woody biomass, particularly in off-grid or mountainous areas with limited access to the grid. Is this going to be for types of processes that have reduced local pollution, such as sulfur oxides (SOx) and oxides of nitrogen (NOx)? Is this strictly combustion or non-combustion as well?
    - CEC Response: The fuel-flexible initiative is focused on using renewable gases (such as hydrogen, biomethane, or ammonia) in distributed generation technologies in demonstrations located at commercial or industrial sites that may be in remote or rural locations, especially those not connected to the grid. Technologies could be either combustion, such as reciprocating engines and gas turbines, or technologies that use electrochemical, thermochemical, or other proven pathways, with very low emissions even without being dependent on emissions control technologies, such as linear generators and fuel cells. Critical infrastructure – like data centers, hospitals, microgrids, telecommunications, academic/research institutions, and others – that need to ensure continuous operations, especially during grid outages, are of particular interest, as these technologies have the potential to replace diesel backup generators. All demonstrations must reduce greenhouse gases and criteria pollutant emissions compared to fossil-fueled generation technologies.
- SoCalGas Comment: Noted existing project on hydrogen-methane blends for fuel cell applications; offered tours of their hydrogen home demo. Question about the

96 CPUC. 2023. Senate Bill 695 Report. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2023/2023-sb-695-report final.pdf

CPUC decision that supported research into blended fuels. Gaps not addressed by the private sector are for field demonstrations of blended fuels and the fuel supply. Recommend outreach to UC Irvine's advanced power and energy programs with Vince McDonald, who is looking at microturbines and changing the combustors for different engines and turbines to accommodate different blends of hydrogen.

  - CEC Response: The CPUC decisions regarding blending targets are in Decision 22-02-025 (February 24, 2022), which sets biomethane targets for utilities, and Decision 22-12-057 (December 15, 2022), which directs utilities to test effects of hydrogen blends up to 20 percent. Please see written public comment no. 5 for CEC's response to the need for funding investments for large quantities of hydrogen blending projects. CEC staff appreciate the recommendation on contacting other stakeholders for information on hydrogen generation.

- SoCalGas Comment: From a research perspective, what are you hearing from the communities around better centering research projects in under-resourced communities or in Environmental and Social Justice communities? Are there any specific actions or procedures being added to your program that you could share with us today?

  - CEC Response: Staff has received feedback from the DACAG regarding the EPIC Program to consider not investing in combustion projects in under-resourced communities. However, staff is working to better understand how that feedback may influence the Gas R&D Program by researching and engaging with DACAG and other stakeholders, such as other environmental justice organizations and environmental groups. Generally, staff is seeking to take their feedback into account during investment planning and throughout the process of developing solicitations, prioritizing equity in investments.

- SoCalGas Comment: Want to encourage CEC staff to share learnings, best practices, and requirements from the CPUC, the U.S. Department of Energy, and other funding agencies to demonstrate improved equity engagement.

  - CEC Response: CEC staff support open communication on sharing best practices to incorporate environmental justice principles in research investments and will work with the CEC's Public Advisor's Office to facilitate this.

- CPUC Staff Comment: Related to the fuel-flexible generation initiative, how is CEC addressing concerns about combustion technologies from the DACAG?

  - CEC Response: There is a CEC-wide effort to expand outreach specifically to communities and community-based organizations around the combustion concern. For example, there was a presentation on January 19, 2024, to the DACAG on the 2024-25 Gas R&D Budget Plan. Currently, with the help of the CEC's Public Advisor's Office, staff is working to better understand the

concern and consider applying feedback within this Gas R&D initiative. For example, in the fuel-flexible initiative, staff is considering limiting new installations to use electrochemical, thermochemical, or other proven pathways, with very low emissions even without being dependent on emissions control technologies and allowing modifications to existing combustion resources, to avoid investing in new combustion demonstrations.

- Tour Engine Comment: CEC has the HyBLOX grant opportunity (GFO-22-504[97]); does CEC have any other program with Federal cost share?
    - CEC Response: The Gas R&D Program is on an annual cadence. In the 2023-24 budget plan, there is an initiative to allow federal cost share. That budget plan is still under evaluation by CPUC. CEC also has a separate funding program called the Clean Hydrogen Program,[98] with a different funding source, that does include federal cost share.

Written Public Comments Received:

Q1: How can equity considerations be centered in the fuel-flexible initiative?

- Mainspring Comment: Equity can be centered in a number of ways; first, siting projects in low-income, disadvantaged, and rural communities, as well as communities that have historically faced outsized impacts from fires and public safety power shutoff ("PSPS") events, empowers these communities through increased resilience and reduced emissions. Second, equity can be centered by ensuring that some component of this program focuses on accelerating deployment of charging infrastructure for medium- and heavy-duty ("MDHD") electric vehicles ("EVs"). Deploying fuel flexible generation, including linear generators, to rapidly energize EV charging stations enables immediate charging of EVs by operating as grid-independent microgrids before utility interconnection, and then serving as clean fuel-powered resilience and flexible load after utility interconnection takes place.
    - CEC Response: Staff concur with the suggestion to have equity as the central focus of the initiative. For the project siting suggestion for using a non-combustion technology in frontline communities, CEC staff concluded that this suggestion would be aligned with addressing the combustion concerns from the DACAG. Taking this approach would help to ensure the project sites in the communities would not have any adverse emissions impacts. Staff will take this into consideration during solicitation development. Having strong application requirements or target metrics for demonstrating the renewable

97 California Energy Commission. GFO-22-504 – Hydrogen Blending and Lower Oxides of Nitrogen Emissions in Gas-Fired Generation (HyBLOX). https://www.energy.ca.gov/solicitations/2023-01/gfo-22-504-hydrogen-blending-and-lower-oxides-nitrogen-emissions-gas-fired

98 California Energy Commission. Clean Hydrogen Program. https://www.energy.ca.gov/programs-and-topics/programs/clean-hydrogen-program

fuel-flexible generation would allow for more direct ratepayer benefits to be quantified.

Q2: How would project siting and/or a community benefits plan help address equity considerations?

- Mainspring Comment: Similar to Mainspring's response to the previous question posed in the R&D workshop materials, siting projects to alleviate the challenges frontline communities face is particularly valuable. This is true not only for residents, but also for the critical infrastructure communities rely on – such as medical facilities, cold storage facilities, data centers, and others that represent commercial and industrial applications where high levels of reliability are of paramount importance. These facilities and the communities they serve cannot afford long-duration outages. As such, a project siting or community benefits plan should incorporate not only the benefits of increased resilience and improved air quality, but also the continuity value of essential services to those communities.
    - CEC Response: Staff concur with siting the clean renewable fuel-flexible generation projects in frontline communities and at critical infrastructure facilities that offer crucial services and cannot sustain any long duration outages. Regarding the suggestions for the community benefits plan, staff also acknowledge the importance of having clean, reliable, fuel-flexible generation to support these essential services in the communities. In response, staff will consider these approaches for incorporation during solicitation development.

Q3: What are the most promising innovations, applications, and technology priorities for fuel-flexible distributed generation?

- Mainspring Comment: Linear generators have strong potential to provide grid benefits in the near-, medium-, and long-term for a number of reasons.... dispatchable, able to quickly ramp up/down ... being fuel flexible ...are highly cost-effective as they can operate on, and readily switch between, hydrogen, ammonia, biogas, natural gas, and propane. ... Finally, by virtue of their modular size (20.5' x 8.5' x 9.5'), linear generators are space- and land-efficient.... The applications for which linear generators provide benefits are broad. ...deployed linear generators across a number of locations in California, including units sited at logistics facilities, grocery stores, wastewater treatment plants, and landfills – and continues to expand the number of units in service.
    - CEC Response: Thank you for highlighting the dispatchable, fuel-flexible, and modular capabilities of linear generators, enabling them to be used in a wide range of applications, including load reduction to the grid. This supports staff's considerations for the innovations and application areas needing support for fuel-flexible generation initiative.

- SoCalGas Comment: A technical priority for fuel-flexible distributed generation is NOx emission control. One specific example of this priority involves pursuing retrofittable solutions for fielded microturbines. Supported by SoCalGas research, development, and demonstration (RD&D), ongoing hydrogen blending research at University of California, Irvine seeks to investigate the impact of various parameters on NOx emissions in microturbines. Fuel-flexible distributed generation holds promise as another innovative solution to decarbonize the current gas grid. This initiative highlights the possibility of utilizing existing gas infrastructure by blending hydrogen with electrolyzer and fuel cell technology, thereby creating microgrids capable of delivering resilient and decarbonized power. Another promising innovation on the horizon involves zero-emission stationary generators. With the backing of SoCalGas RD&D, Noble Thermodynamic Systems is spearheading the development of a retrofit for existing stationary engine reciprocating engine plants.
    - CEC Response: CEC staff concur that NOx emissions control is a technical priority and appreciates the examples provided for pursuing retrofittable solutions for combustion-based technologies such as microturbines and reciprocating engines. Thank you for the explanation of a promising application for decarbonizing the gas grid from the example of the Caltech project for long-duration clean energy storage and dispatchable power generation. This supports staff's considerations for taking a technology-neutral approach that includes both combustion and non-combustion technologies.

Q4: To what extent are you seeing combustion vs. non-combustion technologies as part of fuel-flexible distributed generation in the near- and medium-term?

- Mainspring Comment: Non-combustion generation technologies are key to fuel-flexible distributed generation resources – which itself are an important tool for rapidly adding meaningful capacity to California's grid while simultaneously reducing criteria pollutants and lowering carbon emissions.
- SoCalGas Comment: SoCalGas believes a viable near-term strategy is to retrofit existing combustion technologies to accommodate blends of hydrogen in the fuel supply. In the medium-term, we expect more non-combustion technologies to become available (e.g., fuel cells).
    - CEC Response to both Comments: CEC staff appreciate the different perspectives regarding the timeframe for combustion and non-combustion technologies used in fuel-flexible distributed generation. These technologies may play a crucial role in facilitating our transition towards decarbonization and in response, staff will continue considering a technology-neutral approach under this initiative.

Q5: What gaps are there from private sector investment for advancing fuel-flexible generation that are best addressed by the state?

- Mainspring Comment: Projects in the biogas sector (especially landfills, dairies, and wastewater treatment facilities) are particularly important in demonstrating the value of locally-sited fuel-flexible clean dispatchable generation for a number of reasons produce much more fuel than can be used onsite (which is often flared when unused); capital intensive and ineligible for state incentives (e.g. the Self Generation Incentive Program ("SGIP")); require strong revenue source to offset high capital costs. However, power generated from many biogas facilities, especially landfills, does not produce enough revenue to be economically competitive relative to other Low-Carbon Fuel Standard-eligible projects, which drives investment interest away. Market-based Power Purchase Agreements ("PPA") alone are insufficient to achieve investor return requirements variability in the content of biogenic fuels can vary depending on the source (e.g., landfill, dairy, wastewater treatment), further reinforcing the need for fuel-flexible generation in this important segment state investment to accelerate deployment of charging infrastructure for medium- and heavy-duty vehicles using fuel-flexible distributed power generation is an area that can materially help to meet the state's climate and energy goals – which disproportionately improves air quality for disadvantaged communities by reducing diesel particulates.
    - CEC Response: This initiative is focused on fuel-flexible distributed generation targeted for critical infrastructure, particularly data centers, hospitals, microgrids, telecommunications, academic/research institutions, and others, that need to ensure continuous operations, especially during grid outages. However, staff may consider this suggestion in a future Gas R&D initiative.
- SoCalGas Comment: Large-scale field demonstrations require that the infrastructure accept large amounts of trucked-in hydrogen and the infrastructure to blend that hydrogen with natural gas. Given the absence of private sector investment in this area, the CEC is well positioned to provide the hydrogen blending infrastructure and to provide funding for the large quantities of hydrogen required for these projects.
    - CEC Response: CEC staff welcome the feedback expressing the need for public investment in hydrogen blending infrastructure and for the large quantities of hydrogen needed for these projects. Staff will investigate these suggestions and will take them into perspective during the fuel-flexible solicitation development.

Clean Renewable Hydrogen Distribution: Hydrogen Separation

Public Workshop Comments Received:

- SoCalGas Comment: SoCalGas asked for clarification on how CEC staff is planning to determine end uses. SoCalGas recommended that CEC staff consider that certain end uses may have different gas quality and pressure requirements. For example, fuel cells would require highly pure hydrogen. A variety of hydrogen separation technologies should be explored for a variety of end uses.

    - CEC Response: The technoeconomic analysis portion of the initiative intends to evaluate feasibility and cost-effectiveness of applying hydrogen separation technologies to various end uses. CEC staff agree that gas quality requirements will differ by end use.

- SoCalGas Comment: SoCalGas previously funded a project with HyET to demonstrate and de-risk electrochemical hydrogen separation technologies at a small scale and recommended coordination and collaboration with CEC. For example, CEC can complement SoCalGas' research by targeting larger scale demonstrations. Electrochemical hydrogen separation can also be used as compression, which is important for improving reliability of fuel cell electric vehicle refueling stations that currently rely on mechanical compressors. SoCalGas also has an active project with UC Riverside to evaluate impacts of hydrogen blends on compressed natural gas (CNG) engines to address manufacturer concerns. SoCalGas recommended that this research be conducted now to inform future policy decisions.
    - CEC Response: CEC staff have connected previously with SoCalGas on the HyET project and welcome other opportunities to collaborate on and complement research funded by SoCalGas.
- GTI Energy Comment: This is an important R&D area that pairs well with the Fuel-Flexible Distributed Power Generation initiative. Where de-blending occurs, there may be a hydrogen-rich gas as an output that can be used by on-site generation technology that accepts a wide range of gas quality.
    - CEC Response: CEC staff concur that hydrogen de-blending could be used to supply hydrogen-rich gas to fuel-flexible distributed power generation end uses.
- CPUC Comment: CPUC asked for clarification on how this research will connect with the Hydrogen Roadmap and Strategic Plan funded under CEC's EPIC Program.
    - CEC Response: CEC staff offered to connect offline to provide a more detailed explanation of the scope of the EPIC-funded Hydrogen Roadmap and Strategic Plan projects.

Written Public Comments Received

Q1: Should this research be pursued in the near term? Or wait for clearer policy direction regarding hydrogen blending on a broader scale?

- SoCalGas Comment: This type of research is needed today to help the State meet its pressing goals of carbon neutrality by 2045, as well as Senate Bill 100 and Senate Bill 32. In fact, conducting the research can help to inform the regulators setting policies, analyzing possible scenarios that are economically and technically feasible. R&D helps to inform more robust policymaking and better policy decisions.
    - CEC Response: CEC staff appreciate this feedback and will consider it amongst others to determine prioritization of this initiative.

Q3: Is there additional demand for this technology, aside from the use cases discussed in previous slides?

- SoCalGas Comment: Electrochemical hydrogen separation can also be used for hydrogen compression, for example at a hydrogen fueling station with on-site electrolysis. Solid state compression could improve fueling station reliability. Some natural gas customers use methane as a feedstock for chemical production processes. These customers are known as "feedstock customers," and often cannot utilize hydrogen in their operations. These customers would benefit from deblending upstream from their meters. Also, consider distributed power generation using hydrogen fuel cell power generators. These units could use hydrogen de-blended from the pipeline to produce zero emissions (greenhouse gas and NOx) power for microgrids or backup power applications.
    - CEC Response: CEC staff appreciate this feedback and concur that hydrogen separation technologies are applicable to these use cases.

Q4: What are some resources that can help further inform this research initiative?

- SoCalGas Comment: The CEC can refer to SoCalGas's HyET demonstration, which field tested a technology that can simultaneously separate and compress hydrogen from a blend of hydrogen and natural gas. At scale, the technology would allow hydrogen to easily be transported via the natural gas pipeline system, then extracted and compressed at fueling stations that provide hydrogen for fuel cell electric vehicles (FCEVs). HyET's technology can be designed to achieve simultaneous purification and deblending (from mixtures of nitrogen (N2), hydrocarbons (CxHy), and trace amounts of carbon monoxide and carbon dioxide) and compression of hydrogen, up to >900 bar. The SoCalGas RD&D demonstration ran for approximately 9 months and tested a variety of blending percentages (2 to 20 percent hydrogen in methane) at a flow capacity of 10 kilograms (kg) of hydrogen per day operating at an approximately 6000 pounds per square inch gauge (PSIG). Depending on blend level, extraction typically consumed 4 to 8 kilowatt hours (kWh) per kg hydrogen, and compression consumed 2 to 8 kWh per kg hydrogen. HyET and Baker Hughes also have a collaboration to combine HyET's electrochemical hydrogen compression technology with Baker Hughes' compression technology across a variety of pressure applications to grow and accelerate the hydrogen market. The insights and experiences gained by SoCalGas RD&D through these demonstrations can be used to inform future research and projects.
    - CEC Response: CEC staff appreciate the background and technical metrics provided on HyET and Baker Hughes' hydrogen separation and compression technologies. CEC staff have connected previously with SoCalGas on the HyET project and welcome other opportunities to collaborate on and complement research funded by SoCalGas.

Q5: What are some promising innovations that can further improve separation efficiency, durability, and performance with low hydrogen concentrations?

- SoCalGas Comment: SoCalGas RD&D is supporting a project, directed by Caltech researchers, and funded by Advanced Research Projects Agency - Energy (ARPA-E), that seeks to develop a hybrid electrochemical/catalytic approach for direct generation of high-pressure hydrogen. Caltech's proposed system has the potential to reach <$2 per kg of hydrogen produced and compressed at 700 bar using renewable energy sources. The proposed catalytic compression is estimated to require lower capital expenditures and operating expenses and has much better scalability than incumbent technologies. The team estimates a cost of $0.19 per kg hydrogen for compression to 700 bars, representing a >80 percent reduction compared with state-of-the-art.
    - CEC Response: CEC staff appreciate the background and technical metrics provided on SoCalGas' and ARPA-E's project to develop Caltech's catalytic compression technology.
- Aven Alliance Comment: My name is Karmel Graham, and I am the Founder of the Aven Alliance. We are a nonprofit that consults in the clean energy space. I am also the Director of Product Management for Great Plains Analytical Services (GPAS), which is an emissions testing company headquartered in Oklahoma. Both the Aven Alliance and GPAS are making strides to move clean hydrogen energy forward, yet we've noticed that there is a lack of resources and incentives for hydrogen equipment maintenance and hydrogen gas leak repair. New state and federal rules/guidelines must be created to incorporate this very critical element of the value chain. There is also the need for new tooling and testing equipment to be developed, as everything currently available is not suitable for hydrogen detection. I ask that this be a consideration and focal point in plans moving forward.
    - CEC Response: The FY2023-24 Gas R&D Budget Plan includes a proposed initiative for Gas Leakage Mitigation, inclusive of research on hydrogen leakage detection and mitigation technologies. That budget plan is still under evaluation by CPUC.

Building Decarbonization Networked Geothermal District Heating Study

- SoCalGas comment: There were issues in the Imperial Valley where there's a tremendous amount of geothermal power generation, but they were suffering from decreasing capacity over time.
    - CEC Response: Anticipated performance degradation is a common occurrence in geothermal wells over time. One potential strategy to address this is oversizing the project and factoring in a percentage decrease to ensure the required heating capacity remains available throughout the project's lifespan. Additionally, the district heating system can be complemented by heat pumps or other technologies on exceptionally cold days, with geothermal heating serving as the primary heating source for the majority of the time. Furthermore, it's important to note that the capacity requirements for power generation may differ from those of the proposed district heating system. Thus, the heating system may not encounter the same challenges as the

power generation aspect. In developing a future solicitation, CEC staff will consider evaluations of the estimated life span of the well and anticipated performance degradation, so stakeholders can understand the long-term impacts of the project.

- SoCalGas Comment: In response to Q2: What are the major obstacles that prevent wider adoption of geothermal heating in California? The two major obstacles that prevent wider adoption of geothermal heating in California are brine production and seismic concerns. Geothermal wells often produce brine contaminated with materials that are potentially toxic (e.g., heavy metals) and costly to dispose of. Drilling to geothermal depths in populated areas could raise seismic concerns.
    - CEC Response: In the context of brine, geothermal power necessitates separating non-condensable elements from steam to safeguard turbine blades from damage or reduce maintenance on heat exchangers due to the high flow rates. In geothermal heating systems, the steam or hot water is passed through a heat exchanger and then re-injected into the ground. Some losses occur in this loop, and the brine may be diluted with treated wastewater. The CEC staff don't expect the brine waste volume to be as high as that generated by power generation processes. However, CEC staff will consider including in the solicitation(s) to closely monitor and assess the environmental impact of brine disposal to ensure responsible management practices. Addressing seismic concerns is crucial in the community engagement strategy for such projects. This is similar to large-scale endeavors in populated areas, like driving piles for sizable buildings, as these also require community engagement to minimize disruptions. As part of the study, researching existing gas wells—including those in urban areas or near fault lines with similar seismic concerns—is essential. This research allows for the incorporation of lessons learned from past drilling experiences into the current project planning. Since the drilling is relatively less deep, the potential impact may be minimal. However, as part of the study, this concern will be investigated to ensure a comprehensive understanding of any potential effects.
- SoCalGas Comment: In response to Q2: What type of business models (e.g., gas utilities) could best leverage these (>120 degrees F) geothermal heating resources? Gas utilities are already positioned to provide fuel for heating purposes (customers are billed per therm of energy delivered). Utilities are also skilled at deploying, maintaining, and operating large infrastructure projects and would be well-positioned to provide this type of product.
    - CEC Response: CEC staff appreciate this feedback and concur that gas utilities could have a positive impact on geothermal district heating.

APPENDIX D
List of 2023 Gas R&D Events

January 2023:

- Pre-Application Workshop: Hydrogen Blending and Lower Oxides of Nitrogen Emissions in Gas-Fired Generation (HyBLOX) - GFO-22-504

September 2023:

- IEPR Commissioner Workshop on the Potential Growth of Hydrogen (presentation on hydrogen research portfolio, including Gas R&D Program projects)
- EPIC Policy + Innovation Coordination Group – Strategic Goals Built Environment Workshop (presentation on hydrogen for industrial decarbonization, including Gas R&D Program projects)
- Climate Data Analysis Working Group (C-DAWG) Presentation on Historical Weather Observation Platform (developed under PIR-19-006)

October 2023:

- Presentation on "Advanced Quantification of Methane Emissions Using UAV Curtain Flux Method and Comparison with Flux Chamber Method" at EREF Summit on Quantification of Landfill Emissions (PIR-19-009)
- Presentation on the AB 100 Seismic Safety and Earthquake Preparedness Activities Report to the Seismic Safety Commission, including overviews of related Gas R&D Program projects to improve gas pipeline geohazard risk mitigation (PIR-18-002, PIR-18-003, PIR-23-004)

November 2023:

- Pre-Application Workshop: Quantifying Exposures to Indoor Air Pollutants in Multifamily Homes that Cook with Gas or Alternatives (GFO-23-501)

December 2023:

- Staff Workshop to Discuss Proposed Gas Research Initiatives for FY 2024-25
- Meeting of the California Energy Commission's Healthy, Equitable Energy Transition (HEET) Working Group, covering the theme "Understanding Air Quality and Equity Impacts of Clean Energy Interventions Using Models and Measurements"

APPENDIX E
FY 2024-2025 Gas R&D Plan Equity Framework Topic Definitions

The FY 2024-25 Gas R&D Budget 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 under-represented 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 2). 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 TDD projects that include 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 to further adoption and job creation in geothermal energy.

APPENDIX F
Estimated Administrative Costs

Based on analyses conducted on FY 2023-2024 Gas R&D Program administration, an estimated breakdown of Gas R&D Program administration costs is provided below.

Program Administrative Cost Budget Item	Fiscal Year 2023-2024 ($)
Investment Plan Development	$229,669
Project Planning and Initiation	$504,031
Project Oversight and Governance	$695,214
Stakeholder Communication, Engagement, and Outreach	$116,697
Regulatory Support Compliance	$229,669
Internal Management Coordination	$76,970
Program and Process Coordination and Improvement	$63,121
Administrative Activities	$81,565
Supervision and Personnel	$271,928
Training and Development	$131,136
Total	**$2,400,000**

APPENDIX G
Gas R&D Stakeholders Workshop Presentation

Please see, https://www.energy.ca.gov/event/workshop/2023-12/fy-2024-25-gas-rd-budget-plan-workshop