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CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

Research and Development Division

STAFF REPORT

Gas Research and Development Program

Proposed **Updated** Budget Plan for Fiscal Year 2023–24

February 2025 ~~**May 2023**~~ **| CEC-500-2023-020-REV**

California Energy Commission

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division manages the Gas Research and Development Program, which supports energy-related research, development, and demonstration not adequately provided by competitive and regulated markets. These research investments spur innovation in energy efficiency, renewable energy and advanced generation, energy and distribution, energy-related environmental research, and transportation.

The CEC's Energy Research and Development Division conducts this public interest gas-related energy research by partnering with research and development entities, including public and private research institutions, businesses, utilities, and individuals. This program promotes greater gas reliability, lower costs, and increased safety for Californians.

The *Gas Research and Development Program Proposed Budget Plan for Fiscal Year (FY) 2023–24* is a staff report prepared by the CEC Energy Research and Development Division.

For more information about the Energy Research and Development Division, please visit the Research and Development webpage on the CEC website.

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 (FY) 2023–24. The proposed research and development aligns with the themes of ~~gas leakage mitigation,~~ building decarbonization~~,~~ **and** targeted gas system decommissioning~~, and leveraging cost share opportunities~~. The initiatives support state energy policies and goals, with several initiatives directly benefiting under-resourced communities. The proposed research funding for FY 2023–24 is $24 million and an additional $6,536,142 of supplemental funds, and the budget plan covers July 1, 2023, through June 30, 2024. The budget plan benefited from input from representatives of the Disadvantaged Communities Advisory Group, CPUC and other agency coordination, **Investor-Owned Utilities (IOUs)**, and a public workshop, among other input received on CEC's gas-related efforts.

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

Keywords: California Energy Commission, California Public Utilities Commission, gas, climate change, renewable energy and advanced generation, renewable gas, energy infrastructure, gas pipeline integrity, energy-related environmental research, transportation, disadvantaged communities, low-income communities, decarbonization, hydrogen

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TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

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. The Gas Research and Development (Gas R&D) Program supports this gas sector transition and cost-effective achievement of the state's clean energy and climate goals. Research and development 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.

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), other agencies, and Investor-Owned Utilities (IOUs); and public and Disadvantaged Communities Advisory Group 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.

In response to CPUC guidance in Resolution G-3603, this~~This~~ proposed Fiscal Year (FY) 2023–24 Gas R&D Budget Plan includes R&D funding for **three**~~four~~ initiatives aligned with **two**~~four~~ themes (Table ES-1). The proposed R&D serves to support ~~gas leakage reduction,~~ building decarbonization~~,~~ **and** targeted gas system decommissioning~~, and leveraging cost-share opportunities~~. Funding for these initiatives is requested from the Fiscal Year (FY) 2023–2024 annual budget, as well as $6,536,142 in unspent funds.

The FY 2023–24 Gas R&D Budget Plan benefited from input from representatives of the Disadvantaged Communities Advisory Group, CPUC coordination, **IOU coordination,** and a dedicated public workshop, among other input received on CEC's gas-related efforts.

Table ES-1: Proposed FY 2023–24 Gas R&D Budget Plan

Initiative Themes	Initiative Title	Proposed Budget	Proposed Supplemental Budget
~~**Gas Leakage Mitigation**~~	~~Innovative Gas Leakage Monitoring, Mitigation, and Prevention Solutions~~	~~$6,000,000~~	~~$4,130,876~~
Building Decarbonization	Air Pollutant Exposure Assessment in California Residences	$7,000,000	
Building Decarbonization	**Networked Geothermal District Heating Study**	**$5,640,000**	**$2,405,266**
Targeted Gas System Decommissioning	Scaled-Up Gas Decommissioning Pilot and Integrated Planning Tools	~~$2,000,000~~ **$8,000,000**	**$4,130,876**
~~**Leveraging Cost Share Opportunities**~~	~~Federal and Private Cost Share~~	~~$5,640,000~~	~~$2,405,266~~
Comprehensive Programmatic Evaluation, Under G-3592		$960,000	
Program Administration		$2,400,000	
TOTAL		$24,000,000	$6,536,142
Grand TOTAL		**$30,536,142**	

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 SB 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 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

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

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

3 California Public Utilities Commission Decision 04-08-010. Available at https://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/39314.PDF.

providing benefits to the general public; and consider opportunities for collaboration and cofunding with other entities, such as federal and local agencies.

In 2006, the California Legislature passed SB 1250 (Perata, Chapter 512, Statutes of 2006),[4] 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." 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 AB 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, to align 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 R&D 2022 Annual Report.[6]

Fiscal Year 2023–24 Budget Plan Priorities and Development

The proposed Fiscal Year (FY) 2023–24 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 leakage reduction,~~ building decarbonization~~,~~ **and** gas system planning~~, and leveraging cost share opportunities~~. 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 research gaps; coordination with the CPUC, other agencies, and Investor-Owned Utilities (IOUs); and input from the public and the Disadvantaged Communities Advisory Group (DACAG), as discussed in Chapter 2.

4 Public Resources Code Sections 25620-25620.15 codifies SB 1250 (2006). Available at https://codes.findlaw.com/ca/public-resources-code/prc-sect-25620.html.

5 CPUC website for "Energy Research Development and Deployment," https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/energy-research-development-and-deployment.

6 Werner, Misa. 2022. Energy Research and Development Division. *Gas Research and Development 2022 Annual Report*. California Energy Commission. Publication Number: CEC-500-2022-011, Available at https://www.energy.ca.gov/publications/2022/gas-research-and-development-program-2022-annual-report.

CHAPTER 2:
Developing Gas R&D Initiatives for Fiscal Year 2023–2024

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, public and DACAG input, and state agency roadmaps, as discussed below and in Appendices A–F.

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) [7, 8] and doubling energy efficiency by 2030 (Senate Bill 350, De León, Chapter 547, Statutes of 2015).[9] This year's Gas R&D Program investments advance these objectives by supporting R&D for ~~gas leakage,~~ decarbonizing buildings and developing decision-support tools for the gas system transition. The Gas R&D Program also seeks to leverage federal or private funding to support program goals.

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

- SB 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 (IEPR), which assess major energy trends facing California's electricity, gas, and transportation fuel sectors and provide policy recommendations.[10]
- 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.[11]

The FY 2023–24 Gas R&D Budget Plan also specifically addresses the focus areas identified in CPUC Decision 04-08-10, including ~~renewable technologies (that is, with initiatives in the areas of hydrogen as it relates to gas leakage mitigation),~~ conservation (in other words, building decarbonization), and environmental issues (that is, building decarbonization~~, gas leakage mitigation,~~ and targeted gas system decommissioning). ~~Leveraging cost-share opportunities have the potential of addressing those focus areas, as well as the focus area of energy~~

7 Available at https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

8 Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1279

9 Available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350

10 Available at https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report

11 California Air Resources Board. California's AB 32 Climate Change Scoping Plan.

~~efficiency.~~ 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, requires 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 adds seven new administrative requirements for the FY 2023-24 Budget Plan and beyond. The CEC addressed the new 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 May 15, 2023).
3. Describe collaborative and cofunding opportunities considered (Chapter 2).
4. Summarize IOU coordination on Budget Plan, and provide details on partnership, costs, and cofunding for projects funded by the Gas R&D Program (Chapter 2).
5. Provide a detailed costs breakdown of Gas R&D Program administration (Appendix G).
6. Summarize how the Long-Term Research Roadmap was considered in the development of the budget plan (Chapter 2).
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. **Overarching Principles for developing the framework have been adopted (Chapter 2).**~~However, the framework is not yet established for CEC to use.~~ The resolution also declined to fund the California Sustainable Energy Entrepreneur Development (CalSEED) Gas R&D initiative in the FY 2022–2023 Budget Plan. As such, CEC followed CPUC's direction to submit a Tier 2 Advice Letter to put forth an alternate proposal. Furthermore, CEC removed the CalSEED initiative from the FY 2023–2024 Budget Plan, which had been presented to the DACAG and at the public workshop held January 17, 2023.

CPUC Resolution G-3584

As directed by CPUC Resolution G-3584, issued in 2021, the CEC considered the AB 3232 (Friedman, Chapter 373, Statutes of 2018) report in developing the FY 2023–24 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.*[12] For example, one strategy is to substitute energy-efficient electric appliances for gas appliances to offer efficiency savings and GHG reductions as well as air quality cobenefits. This strategy is addressed by the research initiative "Air Pollutant Exposure Assessment in California Residents." This research initiative supports building decarbonization policy that maximizes health and equity benefits. The initiative will support laboratory and field work to measure

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

health-damaging indoor air pollutant exposures across diverse households using gas fuels or alternative fuels (for example, electric) for cooking. This research could inform future codes and standards and is described in Chapter 3.

CPUC Resolution G-3584 calls for the CEC to consider, when available, the long-term research roadmap for gas technology development, titled *Long-Term Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals*. The final report was submitted to the CEC on November 30, 2022, and a public workshop presenting the findings was held December 12, 2022. The report recommendations 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 will guide future 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 2014–15 to FY 2022–23 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 **(footnote 22)**.

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 2021–22 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 2021–22 Gas R&D Budget Plan or projects proposed in the FY 2022–23 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.

For all Gas R&D Budget Plans, the 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. The goal of this additional step is to ensure the best possible use of funds across programs. In response, the CEC staff provided CPUC staff with summaries of the research initiatives December 6, 2022, and organized a staff coordination meeting December 14, 2022. A summary of this meeting is provided in Appendix C.

13 Available upon request.

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 its proposed plan. Addressing that request, the CEC notes that the noticed CEC lists include Energy Research and Development, PIER Pgm. Residential and Commercial Bldgs. Program Area, Climate Innovation Program, Developing Regulations, Guidelines, and Policies for Implementing SB 350 and AB 802, Clean Transportation Program, General Transportation and Petroleum Issues, Renewable Energy Executive Order, General Natural Gas and LNG Issues, and Disadvantaged Communities Advisory Group (DACAG) will be noticed.[15]

Moreover, the resolution asks that, for all Gas R&D Budget Plans, the CEC consult with the CPUC to allow the option of presenting the budget plan to the CPUC commissioners during a CPUC commissioner committee meeting. CEC staff look forward to consulting further with the CPUC and welcomes the opportunity to present the budget plan to CPUC commissioners, if desired.

CPUC Resolution G-3603

CPUC Resolution G-3603, issued May 9, 2024, approved, in part, the CEC's *Gas R&D Program, Proposed Budget Plan for FY 2023-24* and called for several changes. First, it was ordered that the CEC shall provide detail on the specific initiatives for proposed funding within the Leveraging Cost Share Opportunities initiative theme. In this updated Budget Plan, the CEC proposes to shift the *Networked Geothermal District Heating Study* initiative from the FY 2024-25 Gas R&D Budget Plan to the FY 2023-24 Gas R&D Budget Plan, using the $5,640,000 Proposed Budget previously allocated to the *Leveraging Cost Share Opportunities* initiative.

The resolution also calls for reallocation of the $10,130,876 proposed for the *Gas Leakage Mitigation* initiative theme and directs the CEC to reallocate these funds toward approved research areas, particularly gas system pruning, decommissioning, and safety consistent with CPUC proceedings and policies. Therefore, the CEC recommends allocating these funds to the *Targeted Gas System Decommissioning* initiative.

Moreover, the resolution directs the CEC to be proactive and specific in articulating its coordination and collaboration with the IOUs and other Gas R&D programs in

14 "California Energy Commission Annual Reports." Available at https://www.energy.ca.gov/data-reports/reports/energy-research-and-development-investment-plans-and-annual-reports.

15 CPUC 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, R2008020, R1505006, R2011003.

advance of commencing its plan. Likewise, to ensure that research plans are coordinated, consistent, and aligned with CPUC policies and proceedings, the CEC is ordered to coordinate with CPUC Energy Division and other CPUC staff. Stakeholder Participation and Strategic Partnerships are articulated in a subsequent section of this chapter.

Finally, the resolution states that, once the EPIC program's Uniform Impact Analysis framework is approved by the CPUC, the CEC shall use this framework to demonstrate outcomes of achieving its proposed benefits. While the framework is not yet approved, the CPUC has approved guiding principles of the framework, and their application in this Budget Plan is described in a subsequent section of this chapter, "Foundation Principles for Uniform Impact Analysis."

Commitment to Diversity and Equity

The Gas R&D Program is shaped by the CEC's commitment to diversity and equity. 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 LGBTQ-owned businesses;[16] and economically disadvantaged and underserved communities to participate in and benefit from CEC programs. AB 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 ERDD equity leads work with the CEC's Office of the Public Advisor, Energy Equity, and Tribal Affairs 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 under-resourced entities. In collaboration with the CEC Grants Ombudsman, R&D staff obtains feedback from applicants and implement improvements to the grant application process. In addition, the CEC hosted live online events through the Empower Innovation platform (EmpowerInnovation.net), so community leaders and clean energy technology innovators could meet and learn from each other and start conversations that lead to effective collaboration. Events focused on developing sustainable, affordable housing; providing how-to technical assistance; and navigating grant requirements. 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. In 2021, more than 800

16 As defined by the investor-owned utilities in CPUC General Order 156, http://docs.cpuc.ca.gov/publisheddocs/published/g000/m152/k827/152827372.pdf.

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.* California Energy Commission. Publication Number: CEC-100-2022-001-CMD.

attendees participated in live events. Examples of ongoing efforts to support diversity and equity include:

- Applying an equity scoring criterion to solicitations aimed at supporting under-resourced communities. This criterion considers factors such as economic and public health impacts, as well as community engagement, to help ensure the most direct benefits can be realized from successful applications.
- Continuing to advance efforts to address energy-related challenges and opportunities in under-resourced communities by encouraging residents and interested members of these communities 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.

SB 350 (De León, Chapter 547, Statutes of 2015) also advanced equity in California's clean energy transformation. As outlined in SB 350, the CEC coestablished the DACAG 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.[18] CEC DACAG liaisons coordinate with the 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 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.

Since FY 2016–17, the Gas R&D Program has invested about 71 percent of ~~research~~**program** funds **and an estimated 48 percent of program demonstration funds (excluding projects involving combustion)** to projects in either a disadvantaged community, low-income community, or both. Recent program investments in disadvantaged and low-income communities are included in the *Gas Research and Development 2021~~1~~**3** Annual Report*.[19] CEC staff activities specifically related to CEC's commitment to diversity and equity in the FY 2023–24 Gas R&D Proposed Budget Plan include:

- Presenting and soliciting feedback on the R&D initiatives at the DACAG EPIC subject matter expert meeting January 18, 2023.

18 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.

19 California Energy Commission Energy Research and Development Division. 2023. *Natural Gas Research and Development Program: 2023 Annual Report.* California Energy Commission. Publication Number: CEC-500-2023-054.

- Notifying the DACAG of the January 17, 2023, Gas R&D Plan — Stakeholders Workshop and offering the opportunity for public comment
- **Presenting on the updates to the FY 2023-24 Gas R&D Proposed Budget Plan at the monthly DACAG meeting on January 17, 2025.**
- Regularly meeting with DACAG members to receive recommendations on how to effectively address equity and improve benefits to low-income communities and DACs through proposed R&D initiatives.

CEC staff has helped train under-resourced entities to use the Empower Innovation platform, such as local governments and community-based organizations serving tribes, disadvantaged communities, low-income communities, and opportunity zones. CEC staff are also coordinating additional webinars targeted at local governments and community-based organizations. CEC staff continue to share information on how to use the Empower Innovation Platform, including at preapplication workshops for Gas R&D Program funding opportunities. Empower Innovation technical assistance workshops also provide how-to knowledge to develop winning grant applications.

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

Stakeholder Participation and Strategic Partnerships

The CEC engages with **a variety of** stakeholders to develop a research portfolio that is responsive to challenges in the gas sector. ~~Examples of~~ **For example, CEC**~~annual coordination~~ **coordinates on an annual basis with industry representatives as well as federal regulators, members of the public, and research innovators, including**:

- Southern California Gas Company (SoCalGas) Research, Development, and Demonstration (RD&D) Department on its annual research plans;
- Pipeline and Hazardous Materials Safety Administration and Pipeline Research Council International on gas infrastructure safety and integrity research; and
- Advanced Research Projects Agency–Energy (ARPA-E) on the Rapid Encapsulation of Pipelines Avoiding Intensive Replacement Program.

~~Examples of regular meetings that~~**Additionally,** CEC staff **regularly** participate in ~~relate to the following topics~~**interagency discussions with other state and federal agencies regarding topics that touch on gas sector challenges:**

- California's Fifth Climate Change Assessment (led by the ~~California~~ **Governor's** Office of ~~Planning and Research~~**Land Use and Climate Innovation in partnership with CEC, California Natural Resources Agency, and Strategic Growth Council);**
- Application-driven climate science (led by National Oceanic Atmospheric Administration);
- Forest biomass (led by the California Department of Forestry and Fire Protection ([CAL FIRE]);
- ~~Climate data and analyses to support a resilient energy transition (led by CEC);~~

- ~~Health, energy, and equity (led by CEC);~~
- Hydrogen fuel cell and infrastructure technologies for off-road vehicles (led by the U.S. Department of Energy [DOE] Hydrogen and Fuel Cell Technologies Office);
- Renewable hydrogen hub efforts including fuel cell vehicle and infrastructure issues (led by Governor's Office of Business and Economic Development);
- Transportation and emissions research (led by CARB and South Coast Air Quality Management District); and
- Zero-emission rail (led by the California Department of Transportation ([Caltrans]).

To facilitate technical engagement with key parties in a manner that promotes portfolio-level coordination and relationship-building, CEC staff launched two working groups in 2022. These groups continue to meet approximately quarterly to inform planning for, execution of, and knowledge transfer from applied research:

- **Climate Data and Analysis Working Group (C-DAWG), which invites industry, research, and state agency staff to participate in technical discussions to advance integration of climate change into planning, research, and operations;**
- **Health, Equitable, Energy, Transitions (HEET) Working Group, which hosts discussions on analytical approaches, modeling tools, metrics, and demonstration efforts to advance clean energy policy and deployment strategies.**

The CEC also conducted a public workshop January 17, 2023, to present the Proposed FY 2023-24 Gas R&D Budget Plan. Sixty-seven people attended the workshop, not including the CEC panelists, and the CEC received a dozen attendee questions and comments during the workshop discussion. The CEC considered and responded to stakeholder comments associated with budget plan development. (See Appendices C and D for the staff workshop presentation and a summary of public comments and CEC staff responses, respectively.)

Beyond above-mentioned engagement that informs Gas R&D budget planning, t~~T~~he CEC also engages a diverse set of stakeholders in R&D implementation, **including through the two working groups (C-DAWG and HEET) mentioned above.** 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 ensure the research portfolio delivers 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, stakeholders, and business leaders; and distributing R&D informational materials at conferences, meetings, workshops, and public events, including 11 events in 2022. (A list of 2022 public events are provided in Appendix E.)

In addition to the broad engagement that informs the Gas R&D Program, effective coordination among the CEC, California's gas IOUs, and CPUC is essential to ensure that California's ratepayer-funded Gas R&D program delivers public interest

benefits to ratepayers that align with state energy policies and infrastructure planning as well as state goals for reliability, affordability, and environmental sustainability. Activities listed below reflect ongoing coordination to support strategic gas system planning as well as examples of engagement that supported the design of the FY 2023-24 Budget Plan:

Ongoing Coordination with IOUs:

- **Starting in July 2024, CEC staff participate in biweekly meetings with Pacific Gas & Electric (PG&E), SoCalGas, Sempra, and Southwest Gas to coordinate on topics relevant to the Gas R&D Program—including gas system needs; strategic planning; and relevant state energy goals, policies, and proceedings. Examples of outcomes from these biweekly calls include:**
    - **Proposed alignment of Gas R&D ratepayer benefits between IOUs and CEC to streamline planning, coordination, and reporting across administrators.**
- **Collaboration to organize a joint webinar hosted by SoCalGas, titled "Get to Know California's Gas R&D Programs" on February 6, 2025, demonstrating the complementary nature of administrators' distinct portfolios and examples of project partnerships.**
- **Per CPUC Resolution G-3603 Ordering Paragraph 4, CEC staff are working with the IOU Gas R&D administrators to hold annual public workshops, starting in 2025, to further foster administrator coordination on gas innovation activities to benefit ratepayers and Environmental and Social Justice communities.**

Coordination with IOUs on Proposed 2023-24 Budget Plan Initiatives:

- **In 2023, a CEC Gas R&D funding recipient (DNV-GL, PIR-22-002) and CEC staff met with PG&E and SoCalGas to discuss both potential use of the grant's in-development data-driven tool for prioritizing strategic gas asset decommissioning and the need for more granular hydraulic data. This conversation provided useful insights that helped CEC scope the Scaled-Up Gas Decommissioning Pilots and Integrated Assessment Tools initiatives.**
- **In April 2022, CEC staff met with SoCalGas ahead of its 2023 RD&D Research Plan Public Workshop. Discussion topics included operational differences between the SoCalGas RD&D Program and CEC's Gas R&D Program and opportunities to address overlap or complement work across programs. For example, SoCalGas RD&D tends to have many small projects conducted in collaboration with consortiums like NYSEARCH and Pipeline Research Council International. There are opportunities for successful earlier stage technologies to roll into larger demonstrations with CEC Gas R&D Program support. This conversation served to inform the selection of initiatives proposed in the FY 2023-24 Budget Plan in a manner**

complementary to and not duplicative of SoCalGas's 2023 Budget Plan.

- **CEC staff hosted three workshops (June 9, 2022; June 16, 2022; and December 12, 2022) to elicit stakeholder input regarding decarbonization technologies and associated research gaps to inform research recommendations for the CEC's Long-Term Gas R&D Strategy. SoCalGas participated and provided written comments responding to questions posed at the workshops and offering feedback on the research recommendations. Comments included support for:**
    - **Using limited Gas R&D funding to attract federal funds that are aligned with Gas R&D Program initiatives via cost share grants.**
    - **Researching the role of gas system assets in providing resiliency and reliability for the electric grid during the clean energy transition.**
    - **Identifying alignment on specific recommendations, including the development of a transparent and informed framework for gas system decommissioning opportunities.**

Ongoing Coordination with CPUC:

- **CEC staff host a monthly Gas R&D Working Group call with CPUC Energy Division staff. The working group is a venue for CEC and CPUC staff coordination on Gas R&D Program research projects, priorities, and connections with CPUC proceedings. Examples of relevant outcomes from these calls include:**
    - **Discussion to refine focus of topics—including pilot projects, social scientific research, and air quality research—germane to fostering a gas transition that aligns with affordability, ratepayer concerns, safety, and public health.**
    - **Coordination on data requests to IOUs and associated findings in support of long-term gas planning.**
    - **Sharing of preliminary results from ongoing and recently completed research related to gas system decarbonization to foster knowledge transfer and elicit feedback from CPUC.**
    - **Ongoing discussion regarding the potential for the CEC Gas R&D portfolio to support implementation of SB 1221 and CPUC's broader long-term gas planning efforts.**
- **The CEC contributed to the 2024 Joint Agency Staff Paper: Progress Towards a Gas Transition, including Chapter 8 on Research and Innovation Needs summarizing key research priorities, including those under the Gas R&D Program.**

Coordination with CPUC on Proposed FY 2023-24 Budget Plan Initiatives:

- **On January 16, 2025, CEC met with subject matter experts from CPUC to make clarifications regarding the proposed Geothermal District Heating Study Initiative. The conversation ensured interagency alignment on the initiative goals and led to minor adjustments in the initiative language, such as distinguishing the intended effort from networked geothermal heat pumps and describing the intended site types for Phase I and Phase II efforts.**

Collaborative and Cofunding Opportunities

The CEC engages with a wide range of California stakeholders, including research institutions, governmental agencies, industry, and utility representatives (for example, PG&E, SoCalGas), and the public, to incorporate diverse perspectives on gas public interest energy research projects. The CEC has an ongoing collaboration with PG&E, San Diego Gas & Electric (SDG&E), and SoCalGas, which includes their participation as members of technical advisory committees (TACs) or project teams, or 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 points 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 2021–22 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, South Coast Air Quality Management District), and $5.1 million from private entities. The CEC plans to continue leveraging match to the extent possible~~, and as noted in Chapter 3, CEC plans to leverage federal and private funding opportunities to maximize the impact of the Gas R&D Program~~.

Roadmaps and Technology Assessments

Roadmaps and technology assessments are planning mechanisms and communication tools that 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 "road-mapping" in many program areas to gather cutting-edge information that can help determine how to maximize the value of Gas R&D Program investments.[20] Participants help identify Gas R&D Program research needs in a range of program areas. Collaborative thinking about energy solutions that cut across policy boundaries is integral to leveraging research dollars. Bringing gas and electricity stakeholders together to

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

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

In January 2021, the CEC released a solicitation to develop a research strategy report titled *Establishing a Long-Term Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals.*[21] The study began in June 2021 and used a combination of literature review, technology assessments, prioritization frameworks, and stakeholder input to produce recommendations for the Gas R&D Program. Stakeholder input included TAC meetings, several public workshops, and expert stakeholder interviews. The report has produced a long-term strategy to help decarbonize California by 2045 and has identified prioritized research recommendations in all stages of the gas supply chain and all end-use sectors except utility-scale power generation. The study has identified three research categories: Communities, Equity, and Environmental; Gas End Use; and Gas Supply-Gas Production, Transport and Storage. Across the three categories are 11 recommendations that highlight hydrogen, renewable gas, gas decommissioning, gas safety, carbon capture utilization and storage, and health and equity. These recommendations will help guide future Gas R&D research at the CEC. ~~The study has been submitted to CEC staff and is going through the publication process.~~

Foundational Principles for Uniform Impact Analysis

The Gas R&D Program, similarly to the EPIC program, is designed to provide benefits to ratepayers. A uniform impact analysis framework is being developed in the CPUC's EPIC proceeding (R 19-10-005) with the purpose of demonstrating the realized and potential impacts to electric ratepayers from RD&D investments. CPUC Resolution G-3603 requires that, once this framework is established, the CEC shall demonstrate outcomes of achieving its proposed benefits for all research projects funded by both the EPIC and Gas R&D Programs.

Decision 23-04-042, issued by CPUC on April 28, 2023, included adoption of the following four Foundational Principles for Development of a Uniform Impact Analysis Framework.

- **Each project should offer a reasonable probability of providing benefits to ratepayers, and the portfolio as a whole should demonstrably benefit ratepayers.**
- **If a targeted group of ratepayers benefits from an individual project's output, investments should result in scalable and replicable innovations.**
- **Accurate and precise project and program impacts reporting is needed to ensure impacts are defensible and not overstated.**
- **Lastly, clear and transparent methods of impacts evaluation are required so other parties can verify results.**

The decision emphasizes that benefits should be attributable to the public investment and would not have otherwise occurred and directs the development of methods, metrics, and assumptions in the framework. CEC is committed to

21 https://www.empowerinnovation.net/en/custom/funding/view/9795.

integrating these principles, as well as the framework once adopted, into future Gas R&D planning and reporting.

CEC's current processes are in alignment with these principles in several ways, and impact assessment occurs throughout the Gas R&D Program administration process. For example, in the budget planning phase, initiatives are scoped to ensure replicable and scalable benefits to ratepayers, each considering expected outcomes and describing benefits using a consistent framing. Consultations with parties - including other Gas R&D administrators, CPUC subject matter experts, and interested members of the public - ensure that initiatives will enable proposed projects that fill an identified RD&D gap, such that benefits to ratepayers would not otherwise have occurred. Following the approval of a budget plan, the CEC develops competitive solicitations that progress the objectives of the proposed initiatives. Solicitations, which are more specific than initiatives, may describe the requirements for impact evaluation that are expected in an application and resulting project. Applicants are required to identify project performance metrics that demonstrate research or technology advancements by which to measure the project benefits, as well as to provide a description of the proposed project's benefits to Californians. Once a project is underway, grant managers require tracking and reporting of metrics, and project benefits are reported through multiple avenues, including program annual reports, project final reports, and the CEC's Energize Innovation web platform.

In the Gas R&D Program, as with EPIC, the expected impacts, benefits, and benefit assessment methods will differ by the type of project funded. Gas R&D projects can typically be categorized as applied research studies, technology development, or pilot demonstrations. The FY 2023-24 Proposed Budget Plan contains initiatives that span several project types. The Air Pollutant Exposure Assessment in California Residences Initiative will fund applied research studies. The Scaled-Up Gas Decommissioning Pilots and Integrated Planning Tools Initiative will fund both pilot demonstrations and applied research studies. The Networked Geothermal District Heating Study Initiative proposes two phases; the first will fund a research study, and, based on its findings, the second phase will fund demonstration projects. While pilot demonstrations bring tangible benefits to the targeted community, accompanying research studies can both inform site selection and other criteria for demonstrations as well as assess replicability and scalability of the outcomes. A diverse research portfolio with varying impacts and benefits can minimize the risk of the overall investment plan by preparing for several possible technological, policy, and social futures. Likewise, embedding flexibility in research initiatives further reduces risk and enhances benefits by being responsive to emerging policy and technology needs.

As the Uniform Impact Analysis Framework is developed and adopted, the CEC will continue to integrate the framework and principles into planning and program administration processes.

CHAPTER 3:
Proposed Initiatives for Fiscal Year 2023–2024

Proposed Budget Overview

This proposed FY 2023–24 Gas R&D Budget Plan includes funding for **three**~~four~~ initiatives aligned with **two**~~four~~ program themes (Table 1). The proposed R&D serves to address the following topics:

- ~~Gas Leakage Mitigation~~
- Building Decarbonization
- Support Gas System Planning
- ~~Leverage Cost Share Opportunities~~

The budget also reflects funds allocated for a comprehensive programmatic evaluation, to be overseen by the CPUC, as directed by Resolution G-3592. The following topics may be included in the next planned Gas R&D Budget Plan (FY 2024–25) to ensure coverage of the program:

- Gas Decommissioning
- Gas System Safety
    - ~~Transportation~~
- Renewable Generation
    - ~~Entrepreneur Development~~

Table 1 includes a proposed supplemental budget of $6,536,142 that consists of funds from energy efficiency and transportation research initiatives under past budget plans, such as from cancelled grants and unspent or unencumbered funds.[22] AB 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.[23] As a result, gas research and development funds do not have encumbrance or liquidation dates, since they are continuously appropriated. However, the CEC would endeavor to encumber the funds within two years and have the projects completed and funds liquidated in a total of six years. In this and future plans, the CEC will 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. **Appendix B provides additional information on past Gas R&D Budget Plans' encumbered and unspent funds.**

22 $1,175,266 from a cancelled project from the FY 2016-17 Budget Plan **in Energy Efficiency; $900,000, $634,358, and $1,087,237 from three cancelled projects from the FY 2016-17 Budget Plan in Transportation; $9,281 from unspent and unencumbered funds from the FY 2016-17 Budget Plan in Transportation;** $1,230,000 from unspent and unencumbered funds from FY 2020–21 Budget Plan **in Energy Efficiency; and $1,500,000 from unspent and unencumbered funds from the FY 2015-16 Budget Plan in Transportation** ~~and $2,630,876 from unspent and unencumbered funds from FY 2016-17 Budget Plan~~**.**

23 Bill Text — AB-148 Public resources. (ca.gov).

Table 1: Proposed FY 2023–24 Gas R&D Budget Plan

Initiative Themes	Initiative Title	Proposed Budget	Proposed Supplemental Budget
~~**Gas Leakage Mitigation**~~	~~Innovative Gas Leakage Monitoring, Mitigation, and Prevention Solutions~~	~~$6,000,000~~	~~$4,130,876~~
Building Decarbonization	Air Pollutant Exposure Assessment in California Residences	$7,000,000	
Building Decarbonization	**Networked Geothermal District Heating Study**	**$5,640,000**	**$2,405,266**
Targeted Gas System Decommissioning	Scaled-Up Gas Decommissioning Pilot and Integrated Planning Tools	~~$2,000,000~~ **$8,000,000**	**$4,130,876**
~~**Leveraging Cost Share Opportunities**~~	~~Federal and Private Cost Share~~	~~$5,640,000~~	~~$2,405,266~~
Comprehensive Programmatic Evaluation, Under G-3592		$960,000	
Program Administration		$2,400,000	
TOTAL		$24,000,000	$6,536,142
Grand TOTAL		**$30,536,142**	

Source: California Energy Commission

Proposed Research Initiatives

~~Initiative Theme: Gas Leakage Mitigation~~

~~CPUC Resolution G-3584 directed the CEC to consider the findings in the "Long-Term Technological Development Strategy to Meet Aggressive Statewide Decarbonization Goals" (Long-Term Gas R&D Strategy) in developing future Gas R&D plans. This initiative aligns with recommendations from the Long-Term Gas R&D Strategy to improve gas leakage prevention,~~

detection, and other mitigation solutions (Initiative C3).[24] The Long-Term Gas R&D Strategy highlights potential community and equity benefits of this research, including ignition incident avoidance, reduced leakage exposure, reduced gas supply costs by minimizing losses, and reduced fugitive emissions that contribute to climate change. Furthermore, this initiative responds to recommendations in the *Final 2022 IEPR Update*[25] by advancing technology solutions to enable appropriate leakage measurement and monitoring while making state investments in hydrogen production, storage, and transport infrastructure. Given the DACAG's comments following the FY 2023-24 Gas R&D Budget Plan Workshop, CEC staff expanded the scope of this initiative to address leakage of methane and methane-hydrogen blends, in addition to hydrogen.

Methane is a short-lived, yet potent GHG responsible for about 20 percent of net climate forcing globally and 10.5 percent of carbon dioxide-equivalent emissions in California.[26] In addition to the classification as a GHG, leaked methane causes photochemical reactions that heighten ozone concentrations in the lower atmosphere (troposphere), where it is considered a regional ground-level air pollutant that can cause negative and costly impacts to human health and the environment. Therefore, reducing methane leakage would reduce direct GHG impacts and improve air quality. Many elevated sources of methane are highly random, variable, intermittent, and ubiquitous across sectors. Previous studies have highlighted the potential for underestimated emissions inventories compared to measured emissions using remote sensors — in one case, measured emissions from California underground gas storage fields were around five times higher than reported.[27] A combination of ongoing and widespread remote sensing of point sources and near-continuous regional observation is needed to reduce methane accurately and effectively.[28] There are opportunities to develop technologies and methods to improve the cost-effectiveness of methane emission monitoring and reduction.

While the use of methane remains a significant source of energy in California, clean hydrogen, in varying blends with methane and as hydrogen alone, is being explored as a zero- or reduced-carbon alternative to fossil gas and as a solution for decarbonizing hard-to-electrify sectors. While clean hydrogen significantly reduces global warming impact compared to continued reliance on fossil fuels, when leaked into the air, hydrogen has been found to have an indirect global warming impact. This indirect global warming effect is caused by hydrogen reacting with other molecules in the atmosphere in a way that extends the lifetime and

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24 California Energy Commission. December 12, 2022. "Webinar on Long-Term Gas Research Strategy Recommendations," https://www.energy.ca.gov/event/webinar/2022-12/webinar-long-term-gas-research-strategy-recommendations.

25 Bailey, Stephanie, Jane Berner, David Erne, Noemí Gallardo, Quentin Gee, et. al. February 2023. *Final 2022 Integrated Energy Policy Report.* 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.

26 CARB. March 2017. *Short-Lived Climate Pollutant Reduction Strategy,* https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf; CARB. "California Greenhouse Gas Inventory for 2000-2020 by Gas," https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/ghg_inventory_bygas.pdf.

27 Thorpe, Andrew et al. April 2020. "Methane Emissions From Underground Gas Storage in California," https://iopscience.iop.org/article/10.1088/1748-9326/ab751d/pdf.

28 Duren, Riley et al. February 2022. *"Airborne Remote-Sensing Surveys of CH4 Emissions in California: Fall 2020 Campaign,"* https://ww2.arb.ca.gov/sites/default/files/2022-04/Duren%2020RD011_final.pdf.

increases the concentrations of GHGs like methane, ozone, and water vapor. Recent science suggests that the actual warming power of hydrogen in the atmosphere can be two to six times higher than standard estimates, depending on the time frame.[29] Still, there are large uncertainties in the leakage estimates dependent on emerging supply chain development and knowledge gaps on associated leakage rates. Further technological advancement is needed to improve hydrogen leakage quantification capabilities and inform responsible build-out of emerging clean hydrogen supply chains. Research is also needed to address knowledge gaps in specific leak mechanisms through joints, threads, cracks, and pinhole defects to accurately predict leak flow rates with gas blends with a varying concentration of hydrogen.[30]

Recognizing the need to address gas leakage today and tomorrow to achieve California's decarbonization goals and reduce safety and health risks, the FY 2023-24 Gas R&D Budget Plan proposes to advance methane and hydrogen leakage detection, monitoring, and prevention technologies.

Initiative Title: Innovative Gas Leakage Monitoring, Mitigation, and Prevention Solutions

Initiative Description

This initiative will result in research, development, and demonstrations to improve the sensitivity, accuracy, and cost-effectiveness of technologies and techniques for methane, hydrogen, and blends of methane and hydrogen leakage detection, monitoring, mitigation, and prevention. Because of the high diffusivity and buoyancy of hydrogen, it behaves differently from methane when emitted to the atmosphere. This initiative will target novel sensor approaches needed to account for different dispersion behaviors of hydrogen, methane-hydrogen blends, and methane leakage. Technologies developed will improve the understanding of leakage from gas infrastructure and emerging clean hydrogen supply chains, including production, delivery, storage, and targeted end uses such as refueling stations, power generation, and industrial processes. Furthermore, this initiative will guide improved leakage prevention and mitigation strategies for key points in the supply chain. Results will promote safe, cost-effective, and environmentally responsible maintenance of existing gas infrastructure and future implementation of decarbonization pathways, including clean hydrogen and gas decommissioning.

Background

To reduce the harmful and costly climate impacts of methane released into the atmosphere, California has established a goal of reducing methane emissions by 40 percent below 2013 levels by 2030. Regulatory pathways have been implemented to achieve this goal including SB (SB) 1371 (Leno, Chapter 525, Statutes of 2014),[31] in which the CPUC and CARB adopted rules and procedures to reduce methane emissions from regulated pipeline facilities through

29 Ocko, I. B. and Hamburg, S. P. July 20, 2022. "Climate Consequences of Hydrogen Emissions." *Atmos. Chem. Phys.*, 22, 9349–9368, https://doi.org/10.5194/acp-22-9349-2022.

30 Raju, Arun and Alfredo Martinez-Morales. July 2022. Hydrogen Blending Impacts Study. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF

32 SB 1371, Rules and procedures to reduce methane emissions. https://ww2.arb.ca.gov/resources/documents/senate-bill-1371-natural-gas-leakage-abatement.

the Natural Gas Leak Abatement Program (NGLA).[32] While the NGLA program has demonstrated a 23 percent emission reduction compared to the 2015 baseline, there are opportunities to further develop technologies and methods to improve the cost-effectiveness of methane emission reduction.[33] For instance, technologies such as advanced leak detection and repair techniques and continuous emissions monitoring systems can help in identifying and reducing methane emissions more effectively.

Among funding sources for monitoring and collecting data from high emission methane regions, the CEC's Gas R&D Program has supported the *California Methane Survey*, initiated in response to Assembly Bill 1496 (Thurmond, Chapter 604, Statutes of 2015), in collaboration with CARB and the National Aeronautics and Space Administration that collected data on five campaigns between 2016 and 2018 using an airborne remote-sensing instrument.[34] *The California Methane Survey* recommended further research and development to enhance resolution, reduce uncertainty, support emissions attribution to various sources, and improve data analysis frameworks, especially for hazardous leak detection. *The California Methane Survey* also recommended development and deployment of persistent, wide-area monitoring systems to detect and quantify highly intermittent point sources and understand the relative contributions to regional methane inventories. Through the SUper eMitters of Methane Detection Using Aircraft, Towers, and Intensive Observational Network project, the research team is establishing a sustained, cost-effective, multitiered approach to regional monitoring.

Alternative technologies and methods such as remote sensing can offer more cost-effective surveying that could be performed more frequently. One study found that emerging vehicle-, drone-, and plane-based mobile methane leak detection technologies required improvements in quantification algorithms and reduction of false-positive detection rates.[35] Remote sensing of methane from satellites may also support monitoring, especially of super-emitter events. The FY 2022-2023 State Budget includes $100 million of Greenhouse Gas Reduction Funds to expand the number of satellites launched for methane observations to enhance enforcement capabilities. However, satellite detection methods can involve tradeoffs that may result in undetected fugitive emissions or inability to attribute high emissions to a specific source.[36] More research is needed to improve the performance of these remote-sensing technologies.

Other past research efforts include the ARPA-E Methane Observation Networks with Innovative Technology to Obtain Reduction program, which supported development of early-stage and

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32 CPUC. Gas Leak Abatement OIR R. 15-01-008. https://www.cpuc.ca.gov/about-cpuc/divisions/safety-policy-division/risk-assessment-and-safety-analytics/gas-leak-abatement-oir-r-15-01-008.

33 California Public Utilities Commission and California Air Resources Board. January 5, 2023. *CPUC and CARB Analysis of the Gas Companies' June 15, 2022, Natural Gas Leak and Emission Reports.*, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-policy-division/reports/2022-ngla-joint-report.pdf.

34 Duren, Riley, Andrew Thorpe, Ian McCubbin. 2020. *The California Methane Survey.* California Energy Commission. Publication Number: CEC-500-2020-047, https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-047.pdf.

35 Ravikumar, Arvind, Sindhu Sreedhara, Jingfan Wang, Jacob Englander, Daniel Roda-Stuart, Clay Bell, Daniel Zimmerle, David Lyon, Isabel Mogstad, Ben Ratner, Adam R. Brandt. September 2019. "Single-Blind Inter-Comparison of Methane Detection Technologies – Results From the Stanford/EDF Mobile Monitoring Challenge." *Elementa: Science of the Anthropocene,* https://doi.org/10.1525/elementa.373.

36 Haskett, Jonathan D. April 2022. "Advances in Satellite Methane Measurement: Implications for Fossil Fuel Industry Emissions Detection and Climate Policy." Congressional Research Service, https://sgp.fas.org/crs/misc/IF12072.pdf.

largely stationary, continuous sensors to achieve specific cost and performance targets (such as estimating the location of each leak to within 1 meter and <$3,000/year total system cost).[37] There is an opportunity to build on this past work to enhance and commercialize these technologies and techniques. This initiative can also improve methane leakage monitoring and mitigation for biomethane production and points of interconnection to avoid unintentional product loss as gas utilities increase biomethane procurement from organic waste and dairies, in compliance with Senate Bill 1440 (Hueso, Chapter 739, Statutes of 2018).[38] This initiative builds on active Gas R&D Program-funded research projects on methane monitoring across several scales,[39] biomethane emission characterization,[40] and postmeter residential methane emissions[41] by focusing on improving performance and cost-effectiveness of sensing technologies and leakage mitigation measures.

Blending hydrogen into the existing gas system has been proposed as an approach for near-term emissions reductions, particularly for large commercial, industrial, and power generation end uses. The thermodynamic, transport, and combustion properties of hydrogen are significantly different from those of methane and other fossil gases and require special considerations in developing leakage detection instrumentation. Recent experimental work conducted by UC Riverside suggests that volumetric gas blend leak flow rate increases with higher concentrations of hydrogen gas in the blend. Further research is needed on leak detection, odorization, gas buildup, dispersion dynamics, safety zones, and maintenance and repair procedures to identify potential impacts and risk factors of hydrogen blends.[42] Investigations into the use of methane leakage sensors for hydrogen sensing have mixed results, as some sensors have heightened sensitivities to hydrogen while others will react only to the diluted gas components in a mixture. Research is also needed to determine how existing gas sensors and advanced detection strategies can be developed, adapted, calibrated, or modified for accurate leakage sensing in various blends.[43]

Moreover, the timing of this initiative offers a critical opportunity to demonstrate hydrogen leakage monitoring technologies and techniques in coordination with upcoming clean hydrogen projects. Near-term state, federal, and industry investments are underway to scale-up clean hydrogen production, conveyance, and end use for targeted applications including heavy-duty transportation and power generation.[44] This initiative supports an opportunity to proactively

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37 ARPA-E. "Methane Observation Networks With Innovative Technology to Obtain Reductions (MONITOR) Program," https://arpa-e.energy.gov/technologies/programs/monitor.

38 CPUC Decision 22-02-025. Decision Implementing Senate Bill 1440 Biomethane Procurement Program. February 24, 2022, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M454/K335/454335009.PDF.

39 "PIR-17-015 SUper eMitters of Methane Detection Using Aircraft, Towers, and Intensive Observational Network (SUMMATION)," available at https://www.energy.ca.gov/filebrowser/download/1085.

40 "PIR-19-009 Characterizing Emissions From California Biomethane Facilities," available at https://www.energy.ca.gov/filebrowser/download/754.

41 "PIR-21-008 California Residential Methane Emissions Characterization (CARMEC)," available at https://www.energy.ca.gov/filebrowser/download/4279.

42 Raju, Arun and Alfredo Martinez-Morales. July 2022. Hydrogen Blending Impacts Study. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDFb.

43 NREL. 2022. *Hydrogen Blending into Natural Gas Pipeline Infrastructure: Review of the State of Technology.* https://www.nrel.gov/docs/fy23osti/81704.pdf.

44

design the clean hydrogen supply chain to minimize leakage, avoiding extensive retrofits in the future. Existing hydrogen detection technologies widely used in industry rely on sensing mechanisms with disadvantages including long response and sample preparation time, intensive labor-handling procedures, specific safety certifications for use, frequent maintenance and calibration, and high costs.[45] These technologies are designed primarily to detect hydrogen releases at 1,000–10,000 parts per million (ppm) (0.1 to 10 percent by volume), levels intended to identify and avoid accumulation beyond the lower flammability limit of 4 percent by volume. Further research is needed to develop hydrogen sensors that can detect and measure leakage at lower detection thresholds and across various types of applications and measurement parameters. Because environmental impacts of hydrogen may arise from the cumulative effect at less than ppm levels, the monitoring range of hydrogen sensors must by extended lower by several orders of magnitude, to 0.01 to 1 ppm (0.001–0.1 percent by volume). By lowering the detection limits of hydrogen sensors, lower concentrations of hydrogen can be monitored and measured over a wider monitoring area at levels relevant for atmospheric and environmental modeling.[46]

The CPUC recently adopted two decisions to assess the feasibility and safety considerations of using clean hydrogen to decarbonize the gas system and hard-to-electrify industries. Specifically, SoCalGas will proceed with an initial phase of feasibility studies for the Angeles Link project, a proposed clean hydrogen pipeline system in the Los Angeles region.[47] In addition, California's gas utilities will develop pilot projects to evaluate standards for and impacts of blending hydrogen into the gas pipeline system.[48] Both decisions require utilities to address leakage concerns in their proposed projects. This initiative will complement the gas utilities' work by advancing novel technologies and techniques to enable more effective hydrogen and blended methane-hydrogen leakage detection, monitoring, and mitigation.

This research initiative will improve gas leakage monitoring technologies and techniques to detect, quantify, and attribute point-source emissions to specific infrastructure elements more effectively. This research will help gas infrastructure operators improve efficiency and cost-effectiveness of their maintenance and leak abatement operations, including inspections, repairs, and upgrades. Improved data availability on methane leakage can guide gas transition planning and decarbonization, including gas system decommissioning opportunities. This

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Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES). 2022. "About." https://archesh2.org/; California Energy Commission. 2022. "Staff Workshop on the Implementation of the Clean Hydrogen Program," https://efiling.energy.ca.gov/GetDocument.aspx?tn=247883.

45 European Commission, Joint Research Centre, Arrigoni, A., Bravo Diaz, L. (2022). *Hydrogen emissions from a hydrogen economy and their potential global warming impact: summary report of the Clean Hydrogen Joint Undertaking expert workshop on the Environmental Impacts of Hydrogen*, Publications Office of the European Union. https://data.europa.eu/doi/10.2760/065589

46 Columbia SIPA Center on Global Energy Policy, 2022, *Hydrogen Leakage: A Potential Risk for the Hydrogen Economy*. https://www.energypolicy.columbia.edu/publications/hydrogen-leakage-a-potential-risk-for-the-hydrogen-economy/

47 California Public Utilities Commission, 2022. *Decision 22-12-055 Decision Approving The Angeles Link Memorandum Account to Record Phase One Costs.* https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K167/500167327.PDF

48 California Public Utilities Commission, 2022, *CPUC Acts To Advance Understanding of Hydrogen's Role As Decarbonization Strategy*. https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-acts-to-advance-understanding-of-hydrogen-role-as-decarbonization-strategy.

~~research initiative will also improve hydrogen leakage monitoring technologies targeting sub-ppm levels to enable accurate quantification and wide-area monitoring.~~

~~Forthcoming projects to scale-up clean hydrogen production, infrastructure, and end-use can integrate these technologies to account for and reduce fugitive hydrogen emissions responsibly. Per recommendations from the DACAG, the research will also consider the accelerated deployment of methane sensors to detect leaks and guide decommissioning of gas systems and the leakage behavior of blended methane-hydrogen systems in the context of operational requirements and reflecting leakage of all constituents. DACAG recommendations also informed prioritizing systems adjacent to and within disadvantaged communities, studying leakage variations with infrastructure age and lowering aging-related risks, and evaluating economic impacts of leakage detection and monitoring equipment.~~

~~Given the extent of the diverse investment required to achieve the objectives of this ambitious initiative, CEC will assess whether it is appropriate to augment this initiative with additional funds when developing the FY 2024–2025 Gas R&D Program Budget Plan.~~

~~Ratepayer Benefits~~

- ~~Safety: Leakage of methane, hydrogen, and methane-hydrogen blends pose safety risks. Improved detection and mitigation technologies and techniques will support more effective preventive measures to reduce the risk of ignition incidents and leakage exposure to the public.~~
- ~~Affordability: This initiative will support reductions in product loss and costs associated with methane leakage monitoring and mitigation measures, including repairs of system components, that will result in improved energy affordability for ratepayers. Hydrogen is an expensive fuel to produce, store, and distribute; high leakage rates can affect the economics of the hydrogen supply chain. Proactively addressing leakage will avoid costs from ultimately being passed down to ratepayers when pursuing hydrogen as a decarbonization pathway for gas end uses.~~
- ~~Environmental Sustainability: This initiative will improve quantification and attribution capabilities and gas monitoring technologies, which will guide actions to reduce gas emissions. This initiative will also improve understanding of the indirect global warming impact of hydrogen and develop solutions to better quantify and address leakage.~~
- ~~Equity: Improved data availability and understanding of leakage rates can inform an equitable transition from the existing gas system through decarbonization pathways, including decommissioning and hydrogen. This initiative will help ensure that forthcoming gas system decarbonization efforts have the appropriate tools and data to account for and reduce leakage impacts properly and responsibly.~~

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*.[49] Among the identified approaches for 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, affordable, and low-carbon future. The updated FY 2023-24 Gas R&D Budget Plan proposes two initiatives on the theme of building decarbonization focused on electrification and changes to the supply of energy.

~~As California moves toward a clean energy future, the role of gas in the state's energy system is changing.~~ Complementing state actions, a growing number of California cities are adopting and implementing local building codes that mandate or encourage building electrification in new construction and major retrofits. Replacing gas-fueled technologies with electric counterparts is expected to accelerate over the next few decades and reduce demand for gas.[50] Measurement of nonenergy benefits of cleaner energy technologies inside buildings is important to support and accelerate electrification interventions such as induction stoves.

Prior scientific studies, including efforts funded by the CEC,[51] demonstrate that pollutants from gas combustion in indoor spaces, especially from cooking, pose a threat to the health of residents. California has made substantial progress toward reducing indoor air pollution through efforts such as continuous indoor-outdoor air exchange ventilation as required by the Energy Code and decarbonization efforts that support building electrification. The CEC's California Building Decarbonization Assessment presents electrification of cooking as the best way to further reduce health risks associated with kitchen-generated pollutants.[52]

To support policies effectively and appropriately that maximize health cobenefits of California's clean energy policies, systematic measurement of health impacts of kitchen electrification interventions is needed. For example, CEC's IEPR recommends that "the CEC and other relevant agencies should work to quantify the nonenergy benefits of reducing building emissions, for example, improved public health, where possible, encouraging monetization of these energy-related externalities such that their mitigation of these externalities can increase access to capital for decarbonization projects."[53] Detailed exposure assessment (magnitude, duration, frequency of pollutant exposure) to cooking-related pollutants is necessary to estimate health impacts of decarbonization strategies accurately. Adequate mechanical ventilation is also important for protecting indoor air quality. The 2022 Energy Code adopted in August 2021 incorporated results from CEC-funded research that recommended tightening kitchen exhaust ventilation standards through a performance standard designed to keep pollutant concentrations below health-based thresholds. Characterization of pollutant size

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[49] 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.

50 CEC's *Integrated Energy Policy Report (IEPR) Volume 1: Building Decarbonization (2021)*.

51 Singer, Brett C.; Wanyu Rengie Chan; William W. Delp; Iain S. Walker; Haoran Zhao. 2021. Effective Kitchen Ventilation for Healthy Zero Net Energy Homes with Natural Gas. California Energy Commission. Publication Number: CEC-500-2021-005.

52 CEC's California Building Decarbonization Assessment – Final Commission Report (2021).

53 CEC's Integrated Energy Policy Report (IEPR) Volume 1: Building Decarbonization (2021).

distribution and chemical composition across diverse households can provide insights to ventilation-based strategies and inform future energy codes.

Recognizing the need to understand detailed exposures to indoor pollutants to estimate health effects and thus support building decarbonization strategies, the FY 2023–24 Gas R&D Budget Plan proposes an initiative to assess air pollutant exposures in California homes.

On the supply side, 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. To help meet thermal needs, DOE grants and other efforts are exploring geothermal heating and cooling throughout the country.[54] [55] By using medium-depth geothermal sources, it is possible to replace conventional heating sources for large commercial customers, including district heating systems with central plants. Advancing drilling technologies and identifying viable locations could drive significant innovations in geothermal heating for the building sector.

Initiative Title: Air Pollutant Exposure Assessment in California Residences

Initiative Description

This initiative will support air pollutant exposure assessment in California homes to illuminate health implications of different cooking fuels, with a focus on fossil gas and electricity. Responding to stakeholder input shared with CEC staff at a public workshop in 2022, this initiative will support an innovative approach that involves laboratory and field research. Given the diversity of California households, cooking styles, and other physical and behavioral factors that affect indoor exposures to cooking-related pollutants, this two-pronged approach is the most promising strategy for cost-effectively characterizing determinants of residential indoor exposures to cooking-related air pollution in a way that lends itself to quantitative assessment.

Background

This work will support planning and executing building decarbonization in a manner that maximizes health and equity benefits. Specifically, the exposure assessment framework advanced by this effort will enable accounting for human health benefits of decarbonization.

Indoor air-pollutant exposure data for pollutants such as nitrogen dioxide and fine particulate matter are needed to help measure health impacts of residential building electrification. Gas stove combustion in California homes routinely exposes residents to pollutant concentrations considered harmful outdoors.[56]

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54 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.

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

56 Seals, Brady, and Andee Krasner. 2020. Health Effects from Gas Stove Pollution. Rocky Mountain Institute, Physicians for Social Responsibility, Mothers Out Front, and Sierra Club. https://rmi.org/insight/gas-stoves-pollution-health. California Air Resources Board. 2023. *Indoor Air Pollution from Cooking*. Sacramento, CA. https://ww2.arb.ca.gov/resources/documents/indoor-air-pollution-cooking

While health effects of ambient exposure to residential fossil gas combustion have been extensively quantified, data portraying exposures to cooking-related indoor air pollutants in California homes are extremely limited. The paucity of data derives, in part, from the complexity of factors that affect indoor air pollutant concentrations, such as human behaviors related to cooking and ventilation, technology attributes associated with air-pollution emissions (for example, electric coil burners in stoves, ovens, and toasters) and building attributes (for example, size, envelope).

The proposed applied research would complement and build on a ~~(forthcoming)~~ solicitation **(GFO-23-501), Quantifying Exposures to Indoor Air Pollutants in Multifamily Homes that Cook with Gas or Alternatives[57], supported by the FY 2021**–22 Gas R&D Plan, which at $2 million is under-resourced to attain the ambitious goal of providing a rigorous basis for quantitative exposures assessment across California's diverse regional, demographic, and household behavioral patterns. Research supported by the FY 2021–22 Gas R&D initiative ~~will~~**is** measure**ing** human exposures to health-damaging pollutants from residential cooking in multifamily homes that cook with gas as well as alternatives to gas, such as propane, electric resistance, and induction. Funding from the proposed FY 2023–24 Gas R&D initiative will enable improved characterization of particulate matter emissions associated with cooking fuel (for example, varying by type of fuel) and generated by the cooking process itself (regardless of fuel type). Attributes that may be considered include chemical composition, size distribution, and health impacts.

The proposed initiative responds to CPUC's direction in Resolution G-3571 to support research to "quantify and document impacts to indoor air quality from natural gas appliances and the potential technically feasible improvements and potential risks to indoor air quality that could be achieved from fuel blending or electrification."[58] The initiative will also be coordinated with the California Department of Public Health's Task Force on Indoor Air Quality, which will provide recommendations on approaches to reduce indoor transmission of respiratory pathogens and improve indoor air quality that will be summarized in a 2024 report. Specifically, this research can support task force efforts by providing extensive preliminary indoor air quality data that can influence ventilation strategies and related research.

Expected Initiative Outcomes

Successful execution of this initiative will deliver a framework for quantifying the magnitude and distribution of indoor exposures to cooking-related indoor air pollutants associated with a variety of household and demographic characteristics for fossil gas and alternative fuels. Ultimately, results from this research will facilitate estimation of the value of health benefits associated with building decarbonization.

In addition to bringing critical funds to accomplish ambitious goals related to assessing indoor exposures to cooking-related indoor air pollutants, this initiative provides crucial knowledge to support EPIC 4 Investment Plan Initiative 43 ("Evaluating Air Quality, Health, and Equity in

57 https://www.energy.ca.gov/solicitations/2023-11/gfo-23-501-quantifying-exposures-indoor-air-pollutants-multifamily-homes-cook

58 California Public Utilities Commission, Resolution G-3571 (2020). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M347/K955/347955274.PDF

Clean Energy Solutions"). This initiative aims to provide tools for assessing the health benefits of electrification across a range of socioeconomic and demographic variables.[59]

Ratepayer Benefits

- Environmental Sustainability: By providing foundational data to support quantitative assessment of exposures to health-damaging indoor air pollutants associated with cooking-related fuels and activities, this initiative will help appropriately encourage with incentives and account for benefits of building decarbonization.
- Equity: This initiative will provide support for decarbonizing homes in a way that maximizes local benefits associated with reduced indoor air pollutant exposures. By focusing on diverse housing types including low-income and multifamily homes, this research will benefit equity aspects of building decarbonization.

Initiative Title: Networked Geothermal District Heating Study

Initiative Description

This initiative will study and develop opportunities for geothermal energy sourced deeper than geothermal heat pumps and shallower than power generation to provide economical, large-scale, zero-carbon heating for district heating systems. It will use a two-phased approach. The initiative will focus on larger gas consumers that may already have an existing heating network, such as hospitals, university campuses, and large commercial buildings served by central plants.

Phase I aims to enhance understanding of the potential applications for geothermal district heating in buildings and campuses that are challenging 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. Within this, existing oil and gas wells or brownfield sites will be investigated as potential locations for use, as informed by the California Geologic Energy Management Division (CalGEM), among other sources, for geothermal potential if deemed safe for and amenable to the local communities. . As 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. The comprehensive study would seek to apply the insights gleaned 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 interested parties to estimate costs and benefits when considering using geothermal resources in their respective locations. The study may involve conducting interviews and workshops to engage parties, including campuses and organizations with decarbonization goals. This

59 EPIC 4 Investment Plan Initiative 43 ("Evaluating Air Quality, Health, and Equity in Clean Energy Solutions").

gathered information would be shared in the results, providing Phase II applicants with potential ideas for strong partnerships. The study would also investigate the feasibility of leveraging the existing gas utility workforce, recognizing the potential expertise and acquired skills within local workforces, for implementing geothermal district heating systems.

In Phase II, projects will demonstrate the most promising technologies for drilling a new mid-depth geothermal well or modifying an existing well at one or two suitable sites, based on findings from Phase I. The projects will implement the tools developed and technologies evaluated in the preceding phase and may include testing of existing oil and gas wells in the field in California, based on Phase I findings. Evaluation of these potential locations may reveal that they could be modified or improved to include geothermal heating. Considerations will be given to geological factors, concerns related to induced seismicity, building and campus characteristics, and proximity to densely populated areas that may struggle to electrify. Candidate sites should stand to derive significant benefit from a long-term, carbon-free heating source. Sites that are more challenging may be more advantageous to establish the cost-effectiveness and demonstrate the replicability of the pilot throughout the state.

Background

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 suitable, cost-efficient, or available to replace all larger-sized space conditioning equipment. 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 are enhancing the cost-effectiveness of geothermal power.[60] [61]

During the CPUC Policy and Innovation Coordination Group (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 CPUC provided guidance that this topic could work as part of either the Gas R&D or EPIC program, emphasizing the potential for reducing both gas and heat pump loads in winter.

Distinguishing itself from typical ground-source heat pump loops with shallow bores under 100 meters that cater to heating and cooling, geothermal power for

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

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

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, a mid-depth strategy could instead be employed. Mid-range drilling aimed at heating rather than power generation 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 location. Similar projects have been successful in Iceland and recently at the Peppermill Resort Spa Casino in Reno, Nevada.[62] [63] 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.

Expected Initiative 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 that may now offer significant opportunities because of recent advancements in drilling technologies. Phase I includes developing a detailed map of California that includes geological information and locations of existing buildings and campuses that could benefit from geothermal heating. 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 could offer valuable lessons for replicability and scalability. These selected sites will 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

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[62] 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.

[63] 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/.

needs to be modified, have geological conditions that are easier to drill because of new technology, or are brownfield sites. Potential outcomes could be productive uses of previously low-value real estate and greater access to affordable, clean geothermal heating at the building or district scale. The emphasis will be on showcasing the advanced drilling technologies and innovations that might be replicable throughout California, especially in densely populated areas. A successful demonstration in Phase II would help validate use of the Phase I tool to assess the cost-effectiveness and benefits of implementing networked geothermal for district heating.

*Due to the significant initial investment required for geothermal systems and their relatively low ongoing operating costs, adopting a utility rate-based model or alternative financing strategy may be the most effective approach to facilitate widespread and affordable implementation across the state. By securing a fixed, long-term operating cost structure, geothermal systems can provide a more predictable and stable financial outlook, particularly for meeting baseload heating demand. This stability helps to minimize exposure to market-driven price fluctuations, ensuring greater economic viability and long-term affordability for energy consumers.***Ratepayer Benefits**

- **Adaptation: Enable an alternative pathway to achieving resilient and reliable zero-emission heating, particularly for district heating systems that have few accessible options for electrification. It may also present an opportunity for gas utility companies to diversify as they assist in the energy transition.**
- **Affordability: Sharpen understanding of benefits and applications of a thermal energy model that has stable and predictable fuel-supply costs and opportunities for efficiencies at the district scale. Explore opportunities for utility or other third-party financing models that could further stabilize heating costs via a fixed rate that is more resilient to fuel price volatility.**
- **Safety and reliability: Reduce demand for fossil gas and stress on the electric grid. Potentially increase the safety and efficiency of heating systems for residential and commercial ratepayers that currently rely on onsite combustion.**
- **Equity: Reduce GHG and criteria pollutant emissions in under-resourced communities often disproportionately affected by pollution.**
- **Environmental sustainability: Reduce reliance on fossil gas and encourage the transition to renewable resources.**

Initiative Theme: Targeted Gas System Decommissioning

The role of gas in California's energy system is changing as the state strives toward a clean energy future. Over the next 25 years, state and municipal laws concerning GHG emission reductions will result in the replacement of gas-fueled technologies and will reduce the

demand for fossil gas.[64] These transitions require collaboratively charting a strategic path that manages cost-effectiveness, customer affordability, equity issues, and safety. Prior studies, including research funded by the Gas R&D Program, indicate that large reductions in fossil gas consumption in residential and commercial buildings are necessary to meet the state's climate goals.[65] A growing body of literature on the future of California's gas system affirms and offers insights into the complex challenge of decarbonizing the gas system. Yet important gaps remain regarding how to scale up decommissioning efforts, how to chart a transition that addresses community and consumer priorities, and how to expand the purview of planning approaches to consider multiple factors exogenous to gas system infrastructure.[66] Prior research indicates that a managed gas transition is imperative to address issues related to cost and equity.

Recognizing that a successful transition will require learning from smaller-scale pilots to develop strategies and techniques that can be replicated for larger-scale applications, the FY 2023–24 Gas R&D Budget Plan proposes an initiative that supports scaling up of decommissioning pilots and advances integrated planning for gas system decommissioning.

Initiative Title: Scaled-Up Gas Decommissioning Pilots and Integrated Planning Tools

Initiative Description

This initiative augments the Targeted Gas System Decommissioning research initiative of the same name in the FY 2022–23 Gas R&D Budget Plan with additional funds for projects that will support the scaling up of decommissioning pilots and advance integrated planning for gas system decommissioning. These pilots and tools will provide industry and governance stakeholders with crucial data and experience for decommissioning implementation and strategy development, considering technical and societal aspects of the gas system.

This initiative will support implementing additional pilots for decommissioning segments of the gas system. It will also systematically consider the implications of the experiences observed in pilots that are under consideration, and those that will be newly identified for

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64 CPUC (2020). Order Instituting Rulemaking to Establish Policies, Processes, and Rules to Ensure Safe and Reliable Gas Systems in California and Perform Long-Term Gas System Planning. (R.20-01-007).

65 Mahone, Amber et al. 2018. Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model. California Energy Commission. CEC-500-2018-012. https://www.energy.ca.gov/publications/2018/deep-decarbonization-high-renewables-future-updated-results-california-pathways.

Wei, Max et al. 2017. Building a Healthier and More Robust Future: 2050 Low-Carbon Energy Scenarios for California. California Energy Commission. CEC-500-2019-033. https://ww2.energy.ca.gov/2019publications/CEC-500-2019-033/CEC-500-2019-033.pdf.

Gridworks. 2019. California's Gas System in Transition: Equitable, Affordable, Decarbonized, and Smaller. https://gridworks.org/wp-content/uploads/2019/09/CA_Gas_System_in_Transition.pdf.

Aas, Dan et al. 2020. The Challenge of Retail Gas in California's Low-Carbon Future: Technology Options, Customer Costs and Public Health Benefits of Reducing Natural Gas Use. CEC-500-2019-055. https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/index.html.

66 See, e.g., Bilith, Andy et al. 2019. Managing the Transition: Proactive Solutions for Stranded Gas Asset Risk in California. Environmental Defense Fund. https://www.edf.org/sites/default/files/documents/Managing_the_Transition_new.pdf.

decommissioning. The pilots will be selected to represent a variety of circumstances and geographies, including different climate zones, to examine a range of factors (for example, energy costs, resilience implications, maintenance, and repair staff availability). To advance integrated planning for gas system decommissioning, the initiative will also expand and enhance a planning tool under development by integrating how changes in gas assets and operations may impact electric system capacity needs, operations, and planning across short- and long-term time frames. The initiative will advance consideration of impacts to ratepayers, including the potential for large cost burdens, especially those who may be particularly vulnerable to cost changes.

Background

Gas has been a dominant fuel in California for more than 80 years. Currently, 9 million homes in the state use gas for water heating, and many commercial buildings and industrial processes also rely heavily on gas. California's gas consumption levels across all sectors have remained fairly stable over more than two decades.[67] The strategies needed to reduce fossil gas use are just beginning to be developed.

A successful transition will require learning from smaller-scale decommissioning pilots to develop strategies and techniques that can be replicated for larger-scale projects. It will also require shaping technologies to suit the varied circumstances of gas system users and creating pathways that are attractive and actionable for a variety of consumers and communities. Innovation will also be required to address particularly difficult-to-electrify niches or locations, including consideration of end uses that may be more costly to electrify or customers who are disinclined to electrify due to the cost of transitions or other reasons.

IOUs have identified the need for a more complete and realistic assessment of gas sector decarbonization pathways. This assessment is an important gap that needs to be addressed to chart decarbonization strategies that are robust, pragmatic, cost-controlled, sensitive to gas user needs, and aligned with California's energy goals across the entire energy system. For example, integrated approaches must simultaneously address the timing of infrastructure investments and the pragmatics of upgrades. Examples include electrical panel upgrades or workarounds, financing, supply chain and workforce dynamics, and field-vetted replacement technologies and upgrade packages that are attractive to consumers. At the same time, consumers should be shielded from cost shocks that may have profound consequences, and efforts must be coordinated with energy infrastructure transition timelines and associated vulnerabilities (for example, gas system trimming and escalating costs of providing gas).[68]

To date, government-sponsored energy technology research has not been positioned to consider in depth the role of communities, industries, and gas consumers in large-scale energy transitions, and no large-scale pilots of gas decommissioning have been planned or executed

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67 U.S. Energy Information Administration, "Natural Gas Delivered to Customers in California," 12/30/2021. Includes residential, commercial, industrial, electric power, and vehicle fuel.

68 For example, SMUD Comments on "Data-Driven Tool to Support Strategic and Equitable Natural Gas Decommissioning" (September 2, 2021, CEC 19-ERDD-01 Docket, TN# 239580); SoCalGas comments on Decommissioning Workshop (Nov. 30, 2021, CEC 19-ERDD-01 Docket, TN# 240743); Building Decarbonization Coalition's The Flipside Report: A White Paper on Targeted Geographic Electrification in California's Gas Transition (2021), Greenlining's Equitable Building Electrification: A Framework for Powering Resilient Communities (2019)69 PIR-22-002 -Mindful Decommissioning: A Data-Driven Tool for Prioritizing Strategic Gas Asset Decommissioning, available at https://www.energy.ca.gov/filebrowser/download/4316.

in the state. In continued recognition that large-scale energy transitions are also social transitions, augmentation of this initiative will seek research that further assesses the technical, economic, societal, and cultural circumstances related to reception and fulfillment of decommissioning and electrification efforts, as well the consequences of these efforts.

While small-scale pilot projects are relatively tractable and have limited risk, large-scale deployment is required to achieve California's goals for decarbonization. Larger-scale pilots are thus a logical next step. However, there are unique challenges related to large-scale pilots that require detailed engineering review and analysis and must overcome barriers such as the obligation-to-serve requirement and funding availability for electrification. These technical, policy, regulatory, and funding considerations must be addressed before actual large-scale pilots become feasible. Further, while a Gas R&D-funded planning tool is under development[69] and expected to substantially enhance the state's capacity for planning a strategic transition based on consideration of gas infrastructure data, major gaps remain. These gaps include integration of a more complete accounting of decommissioning costs, consideration of emerging clean energy options, and planning across a range of timescales. That is, there is also a need to better understand how experiences with pilot's map to full-scale transition.

This research initiative has been informed by ongoing interagency coordination between CPUC and CEC staff regarding Gas R&D Program and related policy priorities, and by comments received from the DACAG. Public workshops will inform solicitation development to ensure this initiative is focused for maximum impact in this rapidly evolving space, which will require open discussion across diverse perspectives. Research is expected to commence during the latter stages of CPUC's long-term gas planning rulemaking (R.20-01-007), as well as CPUC's rulemaking to modernize the electric grid for a high distributed energy resources future (R.21-06-017), to be responsive to discussions and decisions associated with those rulemakings.

Expected Initiative Outcomes

State energy planning and regulatory agencies, local governments, utilities, and other key stakeholders expect to use findings from this initiative in California's clean energy transition. The research will **inform** ~~promote a future~~ large-scale decommissioning ~~pilot~~ **efforts** to support a cost-controlled and equitable gas transition.

The pilot projects funded by this initiative will build on existing research on gas decommissioning[68] and leverage insight from stakeholders, including utilities, local governments, environmental and community-based organizations, customers, and property owners. The design of the pilots will be guided by data associated with ongoing research projects, which are identifying and analyzing variables, such as: **infrastructure condition, capacity for electrification, current and projected gas throughput, acquisition costs for consumers, consequences accruing to consumers, critical fossil gas dependencies, safety implications, building electrification, energy equity (including consideration of disadvantaged communities, rural communities, and renters, among others), design of consumer technology and supply chain dynamics, and cost savings by avoiding stranded assets.**

69 PIR-22-002 -Mindful Decommissioning: A Data-Driven Tool for Prioritizing Strategic Gas Asset Decommissioning, available at https://www.energy.ca.gov/filebrowser/download/4316.

- ~~Infrastructure condition,~~
- ~~Capacity for electrification,~~
- ~~Current and projected gas throughput,~~
- ~~Acquisition costs for consumers,~~
- ~~Consequences accruing to consumers,~~
- ~~Critical fossil gas dependencies,~~
- ~~Safety implications,~~
- ~~Building electrification,~~
- ~~Energy equity (including consideration of disadvantaged communities, rural communities, renters, and so forth),~~
- ~~Design of consumer technology and supply chain dynamics, and~~
- ~~Cost savings by avoiding stranded assets.~~

Considering these variables, these ongoing projects will produce detailed deployment plans for prospective pilot sites. The pilot projects are anticipated to include a variety of statewide representative circumstances, such as different climate zones and under-resourced communities.

Complementary to the pilots, the applied research component of this initiative will support development of pathways to strategic energy transition rollout practices that include optimization of technology designs with understanding of community reactions. The research will examine technical, policy, regulatory and funding obstacles in support of deploying larger-scale pilots.

It will build on analyses of large-scale pilots as well as ongoing development[69] of a data-driven tool to identify promising decommissioning sites. Enhancements to the data-driven tool to identify promising decommissioning sites will:

- Integrate gathered technical, economical, and cultural data to ease planning across a range of time horizons.
- Consider technical, energy reliability, policy, regulatory, and funding considerations associated with gas and electricity system interactions.
- Assess consumer- and community-level energy choices.
- **Ensure the design**~~Be designed to~~ reflect**s** emerging understanding about **1) capacities and needs of communities to adapt and contribute to all stages of the energy system transition, 2) the role of gas in ensuring or endangering energy reliability, and 3) opportunities for improved, lower-cost, or easier-to-install technologies.**
- ~~Capacities and needs of communities to adapt and contribute to the energy system transition,~~
- ~~Contribution of gas to energy reliability, and~~
- ~~Potential for improved, lower-cost, or easier-to-install technologies.~~

This initiative builds on the initiative of the same name from the FY 2022-23 Budget Plan and earlier related initiatives on location-specific analysis of

decommissioning and the initial development of a data-driven actionable tool and case studies for decommissioning.

Given the significant allocation of $12,130,876 in funding proposed for this initiative, a breakdown of potential topical areas of focus within the broader initiative are outlined below:

- **Scaled-Up Decommissioning Pilots: Approximately $8,500,000 of the initiative funding may be directed to the advancement of leading-edge decommissioning pilots, including related community and stakeholder engagement.**
- **Integrated Planning Tools: Approximately $2,600,000 of the initiative funding may be directed to the development of integrated planning tools that support scoping, design, and implementation of community-engaged gas decommissioning. Specific activities may include:**
- **Further development and application of the Gas R&D Program-funded data-driven tool or other leading gas decommissioning assessment tools and related assessments of gas decommissioning and targeted electrification.**
- **Development of a guide or playbook for implementing community-engaged gas decommissioning, building on related work, such as the recent national-focused Building Decarbonization Coalition report on obligation to serve as well as the work of other states.**
- **Strategic Evaluation: The remainder of the initiative funding will support strategic evaluation of the impacts of gas decommissioning in California. Specific activities may include:**
    - **Analysis of the benefits of gas decommissioning in the context of community and ratepayer priorities such as affordability, health, resilience, and environmental sustainability.**
    - **Evaluation of gas and electric rate design strategies or other key technology-relevant policy areas important to gas decommissioning.**
    - **Gas decommissioning R&D identified by the Gas Joint Agency Steering Committee and coordinated with Gas R&D Program principals.**
- **Emerging Decommissioning Research Needs: As implementation of this initiative coincides with ongoing evolutions in decommissioning insights, research solicitations will be informed by input from members of the Gas Joint Agency Working Group and coordinated with Gas R&D Program principals.**

Ratepayer Benefits

- Safety: Aging gas infrastructure in California poses safety and integrity risks and challenges. Electrification and decommissioning of gas infrastructure are key strategies for addressing aging gas system infrastructure and avoiding future stranded assets.

- Affordability: This initiative contributes to strategic planning of gas sector decommissioning, which is critical for managing costs and maintaining affordable rates through gas system transition.
- Environmental Sustainability: Applied research to support implementation of decarbonization options for the gas sector is urgent given the accelerated pace needed to meet 2030 and 2050 emissions reductions goals. Decommissioning part of the gas system lowers end-use emissions and can reduce methane leakage. It also helps reduce in-home pollution and detrimental health impacts of gas appliances through electrification.
- Equity: The proposed research examines the potential implications of decommissioning to a wide range of gas system users, including those in disadvantaged communities, and along a variety of dimensions. These dimensions include electrification costs, volatile energy costs that could arise as the number of gas ratepayers' declines, and energy resilience.

~~Initiative Theme: Leveraging Cost Share Opportunities~~

~~Companies developing clean energy technologies often need to obtain funding from several private and public sources to support technology development. This funding includes federal and private grants, which typically have a 20 to 50 percent cost-share requirement. Conducting and implementing unproven, innovative technologies and strategies can carry high levels of risk and may require more funding than a single entity can provide. Furthermore, required match funding is often harder to obtain for underresourced communities. Providing cost-share opportunities within the Gas R&D Program may increase the impact of promising innovations that would otherwise be unable to secure required funding. Moreover, funding opportunities from federal government or private entities are often provided at a national level and providing cost share can help attract funding and projects to California, resulting in potential market growth, expansion, and jobs for California entities.~~

~~Initiative Title: Federal and Private Cost Share~~

~~Initiative Description~~

~~This initiative aims to provide cost share funding to California-based entities that apply for and receive a) an award under an eligible federal funding opportunity announcement (FOA), b) subsequent funding to continue research from a previously awarded federal grant that also received CEC federal cost-share funding, or c) an award from a private or nonprofit funding opportunity. Cost-share funding is available only to projects consistent with the goals and objectives of the Gas R&D Program. These cost-sharing funds are intended to leverage significant funding for climate and energy technology research, demonstration, and deployment in California. Cost sharing helps spread the risk among several funders and allows projects that are larger in scope and scale than any funder may be willing to offer.~~

~~Background~~

~~Over the past few years, the CEC has leveraged significant federal funding for California through EPIC by providing cost-share funding to successful recipients of federal awards. For example, in 2020, the CEC awarded $3 million in EPIC cost-share funds to Lawrence Berkeley National Laboratory (LBNL) for a project that secured a five-year, $100 million contract through the DOE. The CEC's cost share helped LBNL secure the DOE award.~~

This initiative is modeled after the EPIC cost-share initiative, except it would focus exclusively on projects aligned with the goals and objectives of the Gas R&D Program. Industrial decarbonization and transportation are among the most promising cost-share areas. Solicitations resulting from the Federal Bipartisan Infrastructure Law (Infrastructure Investment Jobs Act) and the Inflation Reduction Act are among funding opportunities that could be leveraged.

Like the EPIC cost-share initiative, a CEC solicitation will be created to identify, on an ongoing basis, specific federal FOAs or private funding opportunities aligned with the Gas R&D Program. Elements include the following:

- The solicitation will identify specific requirements for applying maximum CEC cost-share amounts, evaluation criteria, and due dates for submissions. The due date will be in advance of the application submission date in the FOA or private funding opportunity.
- To ensure proposals address DAC stakeholders in underresourced communities, evaluation criteria will include whether the application is supported by local workforce and community-based organizations and that project effects and concerns have been addressed.
- High-ranking proposals will receive a letter of funding commitment that is contingent on the applicant receiving a federal or private award.
- If the applicant does receive the federal or private award, then the CEC willj develop an agreement that identifies the scope, deliverables, schedule, and budget for the CEC funds. The scope and deliverables are focused on the specific benefits of the project to California ratepayers and include a plan that shows support for community and labor engagement; ways that it will advance diversity, equity, inclusion, and accessibility; and ways that it will contribute benefits to disadvantaged communities.
- The CEC staff will manage the resulting agreement while getting insights on the portion of the project not funded by the CEC.

This initiative would use $2,405,266 from past energy efficiency research budget plans that were the result of cancelled grants and unspent or unencumbered funds, as discussed in the Proposed Budget Overview at the beginning of Chapter 3.

Expected Initiative Outcomes

A successful cost-share program would attract additional federal and other funding to California while increasing the competitiveness of California-based organizations in accessing these additional funds, partnerships, and resources. By supporting more and larger projects, the CEC will help encourage and accelerate the development and implementation of technologies and strategies aligned with California's energy goals. Furthermore, cost-sharing opportunities can build connections between funding institutions to continue to pursue mutually beneficial projects.

Ratepayer Benefits

- **Safety:** This initiative may award funding to projects that enhance gas system reliability, such as identifying and addressing gas leaks, and safety challenges associated with gas system pruning.

- ~~**Affordability:** This initiative may award funding to projects developing innovations that can cost-effectively decarbonize residential and commercial buildings, industries, and heavy-duty transportation.~~
- ~~**Environmental Sustainability:** This initiative may award funding to projects that improve environmental health (for example, air quality improvements, GHG reductions, reduced use of fossil gas) or support the state's carbon neutrality goals.~~
- ~~**Equity:** This initiative may award funding to projects that support planning the gas system transition to electrification, especially for underresourced communities.~~

Equity Benefits of Proposed Initiatives

The CEC applies the DACAG Equity Framework[70] to help guide its R&D investments toward equity. Table 2 shows the application of the DACAG Equity Framework in CEC Gas R&D initiatives by illustrating the potential direct and indirect benefits of the initiatives. The framework outlines the key principles of equity for state investments and interventions, including (1 health and safety, (2 access and education, (3 financial benefits, and (4 economic development. (See Appendix F for definitions of these principles.) A fifth principle, consumer protection, is not applicable to the Gas R&D Program and is not included in the table. Direct impacts are expected as a direct result of project implementation, whereas indirect impacts are expected from research and technology innovation advancements more broadly.

70 California Energy Commission. 2018. Disadvantaged Communities Advisory Group Equity.

Table 2: FY 2023–2024 Gas R&D Plan Equity Framework Matrix

#	R&D Topic	Health and Safety	Access and Education	Financial Benefits	Economic Development
~~1~~	~~Gas Leakage Mitigation~~	~~Direct Benefits~~	~~Direct Benefits~~	~~Indirect Benefits~~	~~Indirect Benefits~~
~~2~~ **1**	~~Building Decarbonization~~ **Air Pollutant Exposure Assessment**	Indirect Benefits	Indirect Benefits	Indirect Benefits	Indirect Benefits
2	**Networked Geothermal District Heating**	**Direct Benefits**	**Direct Benefits**	**Indirect Benefits**	**Indirect Benefits**
3	Scaled-Up Decommissioning Pilots and Integrated Planning Tools	Direct Benefits	Direct Benefits	Direct Benefits	Indirect Benefits
4	~~Federal and Private Cost Share~~	~~Indirect Benefits~~	~~Indirect Benefits~~	~~Direct Benefits~~	~~Indirect Benefits~~

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.[71] 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 a CEC business meeting. Project summaries are maintained on CEC's Energize Innovation website,[72] and final reports for completed projects are published on CEC's publication website.[73]

71 https://www.energy.ca.gov/funding-opportunities/solicitations

72 https://www.energizeinnovation.fund/projects

73 https://www.energy.ca.gov/resources/publications/energy-commission-publications

LIST OF ACRONYMS

Acronym	Spelled-Out Terms
AB	Assembly Bill
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_2	Carbon dioxide
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 R&D	Gas research and development
GFO	Grant funding opportunity
GHG	Greenhouse gas
GWh	Gigawatt-hour
IEPR	Integrated Energy Policy Report
IOU	Investor-owned utility
IP	Intellectual property
JAEDI	Justice Access Equity Diversity Inclusion
LBNL	Lawrence Berkeley National Laboratory
Long-Term Gas R&D Strategy	Long-Term Technological Development Strategy to Meet Aggressive Statewide Decarbonization Goals
NGLA	Natural Gas Leak Abatement Program
NOx	Oxides of nitrogen
PICG	**Policy and Innovation Coordination Group**

ppm	Parts per million
PG&E	Pacific Gas and Electric
R&D	Research and development
R&D Program	Public Interest Research, Development, and Demonstration Program
SB	Senate Bill
SoCalGas	Southern California Gas Company
TAC(s)	Technical Advisory Committee/Committees

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 dioxide (CO2): A naturally occurring gas, CO2 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 (GWP) of 1.

Carbon neutrality: CO2 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 CO2 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, or 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 CPUC DACAG web page.

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.
- 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 Program (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 approximately $150 million annually support research and development in areas including 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.

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, and transportation.

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 (H2O), CO2, nitrous oxide (N2O), 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 CO2, N2O 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.

Methane: Methane, also known as CH4, 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 CO2, which lasts for about 100 years in the atmosphere, reductions of methane can create a relatively quick reduction in global warming.

Metric ton: A metric ton is a unit of weight equal to 1,000 kilograms (or 2,205 pounds).

Particulate matter (PM): Any material, except pure water, that exists in the solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, wind-blown dust particles to fine particle combustion products.

Super-emitter: Super-emitters are facilities, equipment, and other infrastructure, typically in the fossil-fuel, waste, or agriculture sectors, that emit methane at high rates. Super-emitter events are periods of methane release that can last between a few hours and several months.

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 2023-24 Gas R&D Program Initiative Themes
- Appendix B: CPUC Resolution G-35484 Funding Encumbrance — Unspent Funds
- Appendix C: Public Comment and CEC Responses
- Appendix D: Gas R&D Stakeholders Workshop Presentation
- Appendix E: List of 2022 Gas R&D Events
- Appendix F: FY 2023-2024 Gas R&D Plan Equity Framework Topic Definitions
- Appendix G: Estimated Administration Cost

APPENDIX A:
Policies Supported by FY 2023-24 Gas R&D Program Initiative Themes

~~Policies Supported by Gas Leakage Mitigation Theme~~

- ~~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 natural 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.~~
- ~~Senate Bill 1440 (Hueso, Chapter 739, Statutes of 2018) requires CPUC in consultation with CARB to consider policies that support the development and use of renewable gas that reduce short lived climate pollutants in the state. CPUC Decision 22-02-025 established short- and medium-term biomethane procurement targets for regulated gas utilities.~~
- ~~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 natural gas produced and imported into California, and review and assess the atmospheric reactivity of methane as a precursor to the formation of photochemical oxidant.~~
- ~~Final 2022 Integrated Energy Policy Report Update, Chapter 4: Emerging Topics[74]~~
    - ~~As part of the CEC's continuing assessment of the role of hydrogen in achieving the state's decarbonization goals, the "Role of Hydrogen in California's Clean Energy Future" section provided an overview of how hydrogen is used today and a look ahead to emerging opportunities, including pursuit of a California Hydrogen Hub, that will shape the state's hydrogen future. The report also addressed the need to minimize hydrogen leakage for climate, safety, and economic reasons.~~
- ~~CPUC Decisions on the Role of Hydrogen as a Long-Term Decarbonization Strategy[75]~~
    - ~~The CPUC adopted two decisions to assess the feasibility and safety considerations of using clean hydrogen to decarbonize the gas system and hard-to-electrify industries. These include a feasibility study for the SoCalGas Los Angeles Link project, a clean hydrogen pipeline system, as well as joint gas utility pilot projects that will evaluate standards for and impacts of blending hydrogen into the gas pipeline system.~~

[74] California Energy Commission, 2022, *Draft 2022 Integrated Energy Policy Report*, Publication Number: CEC-100-2022-001-CMD.

[75] California Public Utilities Commission, 2022, *CPUC Acts To Advance Understanding of Hydrogen's Role As Decarbonization Strategy*. https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-acts-to-advance-understanding-of-hydrogen-role-as-decarbonization-strategy.

- ~~Assembly Bill 209: Clean Hydrogen Program[76]Directed the CEC to establish, among other clean energy programs, a Hydrogen Program that provides financial incentives to in-state clean hydrogen projects for the demonstration or scale-up of the production, processing, delivery, storage, or end use of hydrogen. CEC is required to prioritize projects that reduce sector-wide emissions and maximize air quality, equity, health, and workforce benefits.~~

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 GHG 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 to 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 GHG emissions associated with buildings.

Policies Supported by ~~Leveraging Federal Opportunities~~ Gas Decommissioning Theme

- Assembly Bill 1279 (2022): requires the state to achieve net zero GHG as soon as possible, but no later than 2045, and achieve and maintain net negative GHG emissions thereafter. The bill also requires California to reduce statewide GHG emissions by 85 percent compared to 1990 levels and directs the California Air Resources Board to work with relevant state agencies to achieve these goals.
- IEPR: assesses major energy trends facing California's electricity, gas, and transportation fuel sectors and provides policy recommendations.

[76] California Legislative Information, 2022, *Assembly Bill No. 209 Energy and Climate Change*. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB209.

- Executive Order B-55-18: requires that California's economy achieve carbon neutrality by 2045.
- CPUC Decisions and Resolutions: directs CEC to consider research on topics based on CPUC proceedings and policies. Such as, D.04-08-010 requires that Gas R&D projects: 1) Focus on energy efficiency, renewable technologies, conservation and environmental issues, 2) Support State energy policy, 3) Offer a reasonable probability of providing benefits to the general public, and 4) Consider opportunities for collaboration and co-funding opportunities with other entities.
- **CPUC Long-Term Gas Planning Rulemakings (R.20-01-007, R.24-09-012) and Joint Agency Staff Paper: Progress Towards a Gas Transition: outlines inter-agency coordination to develop strategic plans for reducing fossil gas demand and planning for the future of the gas system.**
- **Senate Bill 1221 (2024): requires CPUC to designate priority neighborhood decarbonization zones on the gas distribution system and to establish a voluntary program to facilitate the cost-effective decarbonization of priority neighborhood decarbonization zones, not to exceed 30 pilot projects across the state.**

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 2022-23 Gas R&D Program budget plans encumbered and unspent. 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, which has been approved at a CEC Business Meeting and 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.

FY 2022-23 Gas R&D Budget Plan Funds Encumbered as of January 2025

Research Area	CPUC FY 2022-23 Approved Budget Plan ($M)	FY 2022-23 Current Budget Plan ($M)	Total FY 2022-23 Funds Encumbered ($M)	Total FY 2022-23 Funds Unspent ($M)
Targeted Gas System Decommissioning	$3.50	~~$3.50~~**4.10**	~~$0~~**0.70**	~~$3.50~~**3.40**
Decarbonization of Gas End Uses	$13.00	$13.00	~~$0~~**11.1**	~~$13.00~~**1.9**
Energy Efficiency	$1.50	$1.50	~~$0~~**1.5**	~~$1.50~~**0**
Gas Pipeline Safety and Integrity	**0**	**3.00**	**2.99**	**0.007**
Entrepreneur Development	$3.60	$3.60	$0	$3.60
TOTAL	$**21.60**	$**21.60**	$~~**0**~~**16.30**	$~~**21.60**~~**5.30**

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

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. This letter was provided to CPUC by May 15, 2023.

Source: California Energy Commission

FY 2021-22 Gas R&D Budget Plan Funds Encumbered as of January 2025

Research Area	CPUC FY 2021-22 Approved Budget Plan ($M)	FY 2021-22 Current Budget Plan ($M)	Total FY 2021-22 Funds Encumbered ($M)	Total FY 2021-22 Funds Unspent** ($M)
Energy Efficiency	~~$~~6.10	~~$~~6.10	~~$0~~**6.10**	~~$6.10~~**0**
Renewable Energy and Advanced Generation	~~$~~4.00	~~$~~4.00	~~$0~~**4.00**	~~$4.00~~**0**
Gas Infrastructure Safety and Integrity	~~$~~4.00	~~$~~4.00	~~$0~~**4.00**	~~$4.00~~**0**
Energy-Related Environmental Research	~~$~~3.50	~~$~~3.50	~~$0~~**3.50**	~~$3.50~~**0**
Transportation	~~$~~4.00	~~$~~4.00	~~$0~~**4.00**	~~$4.00~~**0**
TOTAL	~~$~~**21.60**	~~$~~**21.60**	~~$~~**021.60**	~~$~~**21.600**

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

~~***Energy Efficiency: $6.1m will be committed to upcoming solicitation(s) scheduled for summer 2023. As the focus is on improving industrial carbon capture efficiency/performance and/or utilization, the funds could provide cost share for federal grants (e.g., DOE) or as a standalone targeted solicitation.*~~

~~***Renewable Energy and Advanced Generation: $4m has been committed to solicitation GFO-22-504 and anticipates executing between 2 to 4 agreements and encumbering $4.5m of FY2022-2023 funds in the second half of 2023.*~~

~~***Gas Infrastructure Safety and Integrity: $4m has been committed to solicitation GFO-22-503 and anticipates executing two agreements and encumbering funds in the summer of 2023.*~~

~~***Energy-Related Environmental Research: $3.5m will be committed to upcoming two anticipated solicitations. These solicitations are anticipated to be released in Q3 (Quantifying Exposure to Indoor Air Pollutants in Multi-Family Homes) and Q4 (Location-Specific Analysis of Decommissioning to Support Long-Term Gas Planning).*~~

~~***Transportation: $4m has been committed to solicitation GFO-22-502 and anticipates executing agreements and encumbering funds in the second half of 2023.*~~

Source: California Energy Commission

FY 2020-21 Gas R&D Budget Plan Funds Encumbered

Research Area	CPUC FY 2020-21 Approved Budget Plan ($M)	FY 2020-21 Current Budget Plan ($M)	Total FY 2020-21 Funds Encumbered ($M)	Total FY 2020-21 Funds Unspent** ($M)
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.

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

Source: California Energy Commission

FY 2019-20 Gas R&D Supplemental Budget Plan Funds Encumbered

Research Area	CPUC FY 2019-20 Approved Supplemental Budget Plan ($M)	FY 2019-20 Supplemental Current Budget Plan ($M)	CPUC FY 2019-20 Supplemental Funds Encumbered ($M)	CPUC FY 2019-20 Supplemental Funds Unspent** ($M)
Energy Efficiency	$1.00	$1.00	$**1.0**0	$0
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 Strategic Plan (Cross-Cutting)	$0	$0	$0	$0
Gas Small Grant Program	$2.29	$2.29	$2.29	$0
TOTAL	**$7.29**	**$7.29**	**$76.29**	**$1.00**

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

*~~**Energy Efficiency: as of June 30, 2022, unspent funds $1.00m has been committed to solicitation GFO-22-501 and CEC anticipates executing agreements and encumbering funds in the summer of 2023.~~*

Source: California Energy Commission

FY 2019-20 Gas R&D Budget Plan Funds Encumbered

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

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

~~***Energy Efficiency: As of June 30, 2022, unspent funds $1.64m have been committed to solicitation GFO-22-501, CEC anticipates executing agreements and encumbering funds in the summer of 2023.*~~

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

Source: California Energy Commission

FY 2018-19 Gas R&D Budget Plan Funds Encumbered

Research Area	CPUC FY 2018-19 Approved Budget Plan ($M)	FY 2018-19 Current Budget Plan ($M)	Total FY 2018-19 Funds Encumbered ($M)	Total FY 2018-19 Funds Unspent ($M)
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

Research Area	CPUC FY 2017-18 Approved Budget Plan ($M)	FY 2017-18 Current Budget Plan ($M)	Total FY 2017-18 Funds Encumbered ($M)	Total FY 2017-18 Funds Unspent** ($M)
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
TOTAL	**$21.60**	**$21.60**	**$20.73**	**$.87**

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

**The CEC reallocated $2.03m from Energy Efficiency to Gas Infrastructure Safety and Integrity, Transportation, Energy-Related Environmental Research 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 the Proposed FY 2023-34 Gas R&D Supplemental Budget Plan – **Targeted Gas System Decommissioning**~~Gas Leakage Mitigation~~.*

Source: California Energy Commission

FY 2016-17 Gas R&D Supplemental Budget Plan Funds Encumbered

Research Area	CPUC FY 2016-17 Supplemental Approved Budget Plan ($M)	FY 2016-17 Supplemental Current Budget Plan ($M)	Total FY 2016-17 Supplemental Funds Encumbered ($M)	Total FY 2016-17 Supplemental Funds Unspent ($M)
Energy Efficiency*	$.91	$0	$0	$0
Renewable Energy and Advanced 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.

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

Source: California Energy Commission

FY 2016-17 Gas R&D Budget Plan Funds Encumbered

Research Area	CPUC FY 2016-17 Approved Budget Plan ($M)	FY 2016-17 Current Budget Plan ($M)	Total FY 2016-17 Funds Encumbered ($M)	Total FY 2016-17 Funds Unspent** ($M)
Energy Efficiency*	$7.10	$5.20	$4.03	$1.18
Renewable Energy and Advanced Generation	$4.40	$5.02	$5.02	$0
Gas Infrastructure Safety and Integrity*	$4.00	$3.87	$3.87	$0
Energy-Related Environmental Research	$2.60	$2.69	$2.69	$0
Transportation	$3.50	$4.82	$2.19	$2.63
TOTAL	**$21.60**	**$21.60**	**$17.79**	**$3.81**

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

**The CEC reallocated $1.9m from Energy Efficiency to Renewable Energy and Advanced Generation, Energy-Related Environmental Research, and Transportation research areas due to strong proposals in high-priority research areas.*

**The CEC reallocated $.13m from Gas Infrastructure Safety and Integrity to Renewable Energy and Advanced Generation research area due to strong proposals in high-priority research areas.*

***Energy Efficiency: as of June 30, 2022, unspent funds $1.18m from terminated projects will be included in the Proposed FY 2023-24 Gas R&D Supplemental Budget Plan – **Building Decarbonization**~~Leveraging Cost Share Opportunities~~.*

***Transportation: as of June 30, 2022, unspent funds $2.63m from terminated projects will be included in the Proposed FY 2023-34 Gas R&D Supplemental Budget Plan – **Targeted Gas System Decommissioning**~~Gas Leakage Mitigation~~.*

Source: California Energy Commission

FY 2015-16 Gas R&D Supplemental Budget Plan Funds Encumbered

Research Area	CPUC FY 2015-16 Supplemental Approved Budget Plan ($M)	FY 2015-16 Supplemental Current Budget Plan ($M)	Total FY 2015-16 Supplemental Funds Encumbered ($M)	Total FY 2015-16 Supplemental Funds Unspent ($M)
Energy Efficiency	$0	$0	$0	$0
Renewable Energy and Advanced 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.

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

Source: California Energy Commission

FY 2015-16 Gas R&D Budget Plan Funds Encumbered

Research Area	CPUC FY 2015-16 Approved Budget Plan ($M)	FY 2015-16 Current Budget Plan ($M)	Total FY 2015-16 Funds Encumbered ($M)	Total FY 2015-16 Funds Unspent** ($M)
Energy Efficiency	$7.10	$7.10	$7.10	$0
Renewable Energy and Advanced Generation	$5.80	$5.80	$4.62	$1.18
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
TOTAL	**$21.60**	**$21.60**	**$18.91**	**$2.68**

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

***Renewable Energy and Advanced Generation: unspent funds $1.18 has been included in a supplemental budget plan approved by CPUC.*

***Transportation: as of June 30, 2022, unspent funds $1.50m from terminated projects will be included in the Proposed FY 2023-34 Gas R&D Supplemental Budget Plan – **Targeted Gas System Decommissioning**~~Gas Leakage Mitigation~~.*

Source: California Energy Commission

FY 2014-15 Gas R&D Budget Plan Funds Encumbered

Research Area	CPUC FY 2014-15 Approved Budget Plan ($M)	FY 2014-15 Current Budget Plan ($M)	Total FY 2014-15 Funds Encumbered ($M)	Total FY 2014-15 Funds Unspent ($M)
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.

**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.*

Source: California Energy Commission

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 two coordination meetings with California Public Utilities Commission (CPUC) staff, and two meetings with the Disadvantaged Communities Advisory Group (DACAG) representatives on proposed initiatives for the FY 2023-24 Gas Research and Development (Gas R&D) Program Budget Plan. The workshop and meetings are summarized below. The comments and CEC staff responses for each are provided in the following sections:

- On September 28, 2022, and December 14, 2022, CEC staff held coordination meetings with CPUC staff to present the proposed budget plan and received questions and comments from CPUC staff that provided helpful input and perspective on specific research topics and suggested potential research areas.
- On January 24, 2023, CEC staff held a public workshop to present the proposed budget plan and received comments from stakeholders supporting the proposed initiatives and offering helpful input and perspective on specific research topics. CEC staff also received written public comments that have informed this proposed plan.
- On January 18, 2023, CEC staff met with representatives of the DACAG, and on January 20, CEC staff met with the full DACAG to present the proposed budget plan. In these meetings, CEC staff received comments from stakeholders supporting the proposed initiatives and offering helpful input and perspective on specific research topics as they relate to under-resourced community needs.

CPUC Staff Coordination Meeting Comment Summary and CEC Responses

Staff from CEC's Energy Research and Development Division held meetings with staff from CPUC's Energy Division and Safety and Enforcement Division. At the meeting, CEC staff presented the four proposed initiatives for the FY 2023-24 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. Staff received clarifying questions, not comments, regarding the building decarbonization and cost-share initiatives, which are not included here. Regarding the Entrepreneurial Development initiative, CPUC staff had questions regarding the scope of the prospective work area, the expertise of the third-party administrator, and overhead rates. As noted in the FY 2023-24 Gas R&D Program Budget Plan, CEC removed the proposed Entrepreneurial Development initiative from the FY 2023-24 Budget Plan due to the guidance received in Resolution G-3592.

Initiative Theme: Gas Leakage Mitigation

This initiative has been removed from the updated Budget Plan, but received comments and CEC responses at the time of original budget plan submission are included for completeness.

Comment Received:

CPUC staff asked for an update on the hydrogen funding that the CEC will administer following the State Budget Acts of 2021 and 2022, and whether there were updates for 2023.

CEC Response:

The Clean Hydrogen Program was established by AB 209 (The Energy and Climate Change budget bill, Chapter 251, Section 12, Chapter 7.6, Article 4, enacted in September 2022) to demonstrate or scale-up hydrogen projects that produce, process, deliver, store, or use hydrogen derived from water using eligible renewable energy resources, or produced from these eligible renewable energy resources.[77] CEC is administering $100 million of General Funds for the Clean Hydrogen Program. A staff workshop was held on December 1, 2022, to discuss program scope and project eligibility, requirements, and considerations. The Clean Hydrogen Program is not intended to advance hydrogen leakage mitigation solutions. The proposed technical scope is to stimulate increased production and use of clean hydrogen in California through strategic demonstration and deployment of large-scale centralized clean hydrogen production, onsite/distributed clean hydrogen production and use, and federal cost share.

Comment Received:

CPUC staff suggested research into tools for evaluating gas market issues relating to rising gas and electric prices during the winter of 2022-23. CPUC staff also asked if there were research opportunities in improving efficiency of gas storage operations, pipeline safety, or efficient upgrades for compressors.

CEC Response:

The CEC has an active portfolio of Gas R&D Program projects focused on improving gas infrastructure safety and integrity. A ~~recent~~ solicitation (GFO-22-503 Gas Pipeline Safety and Integrity Research to Support Decarbonization)[78] intends to fund research projects on 1) using remote and embedded sensors to monitor and assess risk of natural force damages to gas pipelines, and 2) non-destructive inspection technologies to evaluate the integrity of plastic pipelines more effectively. The CEC also has ongoing projects demonstrating the use of an array of embedded sensors (optical, electromagnetic, acoustic, pressure) to enable continuous and high-resolution gas

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[77] CEC. 2022. Clean Hydrogen Program. https://www.energy.ca.gov/programs-and-topics/programs/clean-hydrogen-program#:~:text=The%20Clean%20Hydrogen%20Program%20provides,help%20reduce%20sector%2Dwide%20emissions.

[78] CEC. 2022. GFO-22-503 Gas Pipeline Safety and Integrity Research to Support Decarbonization. https://www.energy.ca.gov/solicitations/2022-11/gfo-22-503-gas-pipeline-safety-and-integrity-research-support-decarbonization

storage well integrity monitoring. The Innovative Gas Leakage Monitoring and Mitigation Solutions initiative will expand on this portfolio and seek to improve efficiency and cost-effectiveness of methane leakage monitoring and mitigation.

CEC staff is also engaging with the California Geologic Energy Management Division (CalGEM) to determine underground gas storage research and innovation opportunities in the context of their active rulemakings[79], such as the SB 463 Chemical Inventory and Root Cause Analysis rulemaking. CEC staff is sharing research findings from past and ongoing Gas R&D Program-funded projects on quantitative risk assessment frameworks and well integrity monitoring technologies. This engagement will inform future solicitation scoping for the Innovative Gas Leakage Monitoring and Mitigation Solutions initiative, implementation of the approved Large-Volume Hydrogen Storage in California for Targeted Use Cases initiative from the FY 2022-23 Plan, and planning efforts for the FY 2024-25 Plan.

Regarding gas markets and interplay with the electricity system, the initiative titled Scaled-Up Gas Decommissioning Pilots and Integrated Planning Tools from the FY 2022-23 Gas R&D Program Budget Plan (and proposed for additional funding in the FY 2023-24 Plan) includes a complementary applied research component to develop an enhanced, data-driven tool that considers cost impacts of gas and electricity system interactions.

Comment Received:

CPUC staff requested clarification on the public benefit of hydrogen leakage mitigation research if private industry is concerned about losses to improve economics. CPUC staff also requested clarification for how this initiative will coordinate, avoid overlap, and/or explore co-funding opportunities with other hydrogen-related efforts including the recently approved utility hydrogen work including the Angeles Link feasibility studies and Joint IOU Hydrogen Blending Demonstrations, the Hydrogen Leak Mitigation and Regional Clean Hydrogen Hub (ARCHES) hydrogen hub, and other projects funded by the U.S. Department of Energy (DOE). CPUC staff also requested clarification on how hydrogen leakage impacts greenhouse gases (GHGs) and climate change including the magnitude of the potential impacts and status of the science.

CEC Response:

Clean hydrogen is a zero-carbon alternative to fossil gas and is actively being explored as a solution for decarbonizing the gas system and hard-to-electrify sectors. Hydrogen has an indirect global warming impact by reacting with other molecules in the atmosphere in a way that extends the lifetime and increases the concentrations of GHGs like methane, ozone, and water vapor. Recent science suggests that the actual warming power of hydrogen in the atmosphere can be two to six times higher than standard estimates depending on

[79] California Department of Conservation. 2023. Active Rulemakings. https://www.conservation.ca.gov/index/Pages/rulemaking.aspx

the timeframe.[80] Therefore, the warming effects from hydrogen leakage are considered consequential. There are large uncertainties on the magnitude of its potential impacts, as this will depend on emerging hydrogen supply chain development and knowledge gaps on associated leakage rates. Without appropriate mitigation measures and technologies to support monitoring and quantification, expansion of hydrogen infrastructure will result in commensurate hydrogen leakage, which can lead to economic losses, safety risks, and indirect global warming impacts. Although industry may consider the costs of leakage under a certain threshold acceptable, losses due to leakage can be passed down to customers, impacting affordability.

Considering near-term investments to scaling up clean hydrogen production and use, the timing of this initiative is a critical opportunity to demonstrate hydrogen leakage monitoring technologies and techniques in coordination with early pilots and scale-up efforts. For example, large-scale clean hydrogen production projects funded through the CEC's Clean Hydrogen Program can be prime candidates for demonstrating novel sensor approaches for hydrogen leakage monitoring. This initiative will complement the gas utilities' hydrogen blending pilots and Angeles Link feasibility studies by advancing novel technologies and techniques to enable more effective hydrogen leakage detection, monitoring, and mitigation.

CEC staff have been coordinating with ARCHES as participants in the working groups following the concept paper submission. Staff are also supporting evaluation of proposals submitted to ARCHES that would be part of the full proposal to DOE in April. CEC also submitted a Memorandum of Commitment to ARCHES and is considered one of the project partners.

In addition, GFO-22-304, Assessing the Role of Hydrogen in California's Decarbonizing Electric System (which supports the 2021 EPIC Interim Investment Plan initiative titled "The Role of Green Hydrogen in a Decarbonized California—A Roadmap and Strategic Plan"), will fund research focused on production from renewable electricity and end-use conversion technologies for electric sector applications. One of the goals of the research is to help plan and prioritize future hydrogen investments in the context of EPIC and other programs.

Comment Received:

CPUC staff requested clarification on whether the Innovative Gas Leakage Monitoring and Mitigation Solutions initiative targets existing gas infrastructure or new pipelines for hydrogen delivery.

CEC Response:

[80] Ocko, I. B. and Hamburg, S. P., 2022, *Climate consequences of hydrogen emissions*, Atmos. Chem. Phys., 22, 9349–9368, https://doi.org/10.5194/acp-22-9349-2022.

There is value in hydrogen leakage research for both the existing infrastructure and in new pipelines. This initiative would focus on informing multiple decarbonization pathways including future decommissioning opportunities, dedicated hydrogen pipeline infrastructure, and existing system adaptation for hydrogen-methane blending.

Comment Received:

CPUC requested clarification on whether CEC or other entities like DOE should conduct gas leakage monitoring and mitigation research. CPUC staff also requested information on co-funding opportunities.

CEC Response:

The CEC regularly conducts stakeholder meetings to explore and determine coordination opportunities. The CEC will continue to collaborate with other entities, including the DOE, to determine whether the CEC or other stakeholders should take the lead on research areas. The CEC has a unique opportunity to leverage other active hydrogen investments including the Clean Hydrogen Program (i.e., clean hydrogen production facilities) and Clean Transportation Program (i.e., hydrogen refueling stations) to demonstrate novel hydrogen leakage sensing approaches in the field.

Initiative Theme: Building Decarbonization

CPUC comments on Geothermal District Heating Study were made in November 2023 when this initiative was developed for the FY 2024-25 Gas R&D Budget Plan. They are included in both Budget Plans for completeness.

Comment Received:

CPUC staff asked for clarity on the connection between networked geothermal district heating and its impact on gas ratepayers.

CEC Response:

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.

Comment Received:

CPUC staff sought clarification on the rationale for bypassing ground source heat pumps.

CEC Response:

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

In addition to the comments below, the DACAG members inquired about the impacts of the Gas R&D Program. Staff provided a link to the latest Gas R&D Program Annual Report, which includes a high-level overview, and a link to Energize Innovation, which includes project specific summaries, including goals and benefits.

The DACAG members asked clarifying questions about how the Entrepreneurial Development and Cost Share initiatives would work, which are not summarized here. As previously noted, CEC removed the proposed Entrepreneurial Development initiative from the FY 2023-24 Budget Plan Due in response to Resolution G-3592.

Initiative Theme: Gas Leakage Mitigation

This initiative has been removed from the updated Budget Plan, but received comments and CEC responses at the time of original budget plan submission are included for completeness.

Comment Received:

Hydrogen Leak Mitigation and Regional Clean Hydrogen Hub (ARCHES)

The DACAG supports research to improve hydrogen leak mitigation to address safety and indirect climate change impacts from hydrogen infrastructure. We further support this research where it can be co-located with methane leakage monitoring and detection improvements (see below). This includes studying leakage of blended fuel streams and behavior under the increased pressure required to blend hydrogen into existing gas infrastructure. We request this research be prioritized for systems adjacent to and within disadvantaged communities (DACs). We further suggest studying how leakage might vary as infrastructure ages, including from the direct impact of hydrogen use (e.g., pipeline embrittlement), and the materials and monitoring needed to mitigate aging-related risks. We also recommend that this research and the ARCHES include an economic component (i.e., how do leakage detection and monitoring equipment and activities impact the economics of hydrogen as a fuel as compared to other fuel and generation options with less risk) and that they rapidly increase our understanding of the feasibility and details of potential future markets and use cases for hydrogen. The significant international excitement regarding hydrogen production should be cautiously analyzed with respect to likely/feasible applications so we avoid wasted investment and time. In recent analyses of pathways to the goals and requirements of SB 100, many scenarios do not rely on hydrogen at all, an indicator of the questions still to be answered regarding its viability, applications, costs, and market. As one example, please see recent analysis by Energy Innovation at: https://www.youtube.com/watch?v=xNqEh6wCWOc (accessed 2.17.2023).

Gas System and Safety: Methane Leaks

Due to the catastrophic climate impacts and dangerous indoor and outdoor pollution profiles of methane emissions, we recommend moving this priority from the 2024-25 research slate up to the 2023-24 research slate. We recommend accelerated deployment of

methane sensors and increasing the use of satellite technologies to detect methane leaks. We further recommend that the 2024-25 research slate include accelerated gas decommissioning, prioritizing gas systems with high rates of leakage and further prioritizing the decommissioning of these leaky systems within DACs. In cases where there are proposals to mix hydrogen into existing gas supplies, we recommend analyzing leaks in the context of the operational requirements of these systems and reflecting leakage of all constituents.

CEC Response:

The CEC appreciates the DACAG's support for research to improve hydrogen leakage mitigation to address economic, safety, and climate change impacts. The CEC also acknowledges the DACAG's support for "co-locating this research with methane leakage monitoring and detection improvements, including studying leakage of blended fuel streams and the behavior of blended hydrogen under increased pressure when injected into the existing gas infrastructure system." In response to comments from the DACAG and CPUC staff, CEC revised the proposed initiative theme from Hydrogen Leakage Mitigation to, more broadly, Gas Leakage Mitigation and expanded its scope accordingly. When developing the solicitation, the CEC will consider gaps and opportunities to build on progress made in other hydrogen blending efforts including the Joint IOU Hydrogen Blending Demonstrations and CEC's active research related to safety, integrity, and performance impacts of hydrogen blends on large commercial and industrial equipment, power generation, and infrastructure.

The CEC concurs with DACAG's request that research be prioritized for systems adjacent to and within disadvantaged communities. The CEC acknowledges that disadvantaged communities have experienced a disproportionately negative impact from the energy system due to higher air pollution, energy cost burden, and the proximity of large gas end-uses such as power plants. Gas R&D Program solicitations require or give preference to projects that benefit disadvantaged communities. The future solicitation(s) developed under this gas leakage mitigation initiative may include additional requirements such as a preference for testing and demonstration sites to be located within or adjacent to disadvantaged communities.

The CEC concurs with DACAG's recommendation for the research to study leakage variations with infrastructure age, materials, and monitoring solutions to mitigate aging-related risks, and to study economic impacts of leakage detection and monitoring equipment. The Gas R&D Program has several active and forthcoming projects focused on monitoring and detection needs for aging gas pipelines.

CEC staff concurs with DACAG's comment regarding the need to increase understanding of the feasibility and details of potential future markets and use cases for clean hydrogen, including the economic impacts of leakage detection and monitoring activities. The 2021 SB 100 Joint Agency Report excluded drop-in renewable fuels, including green hydrogen, due to the lack of commercially available

technology, inadequate cost and supply data for modeling, or both.[81] The EPIC Program is funding research to further assess hydrogen's role in California's decarbonizing electric system and potential intersections with other end-use sectors such as transportation and industrial, building on current analyses of SB 100 scenarios and the 2022 Scoping Plan Update.[82] When developing the future solicitation for this initiative, CEC staff will consider project requirements around these points and explore connections with other Gas R&D Program and EPIC Program funded research to maximize learnings, inform strategic investments, and answer questions regarding hydrogen's viability across end-uses. Additionally, CEC staff will continue to track investments and opportunities to coordinate with the ARCHES hydrogen hub and the AB 209 Clean Hydrogen Program.

Considering recommendations from CPUC staff and DACAG, the CEC is proposing additional funds for gas decommissioning research in the FY 2022-23 and FY 2023-24 Gas R&D Program Budget Plans, leveraging the Scaled-Up Gas Decommissioning Pilots and Integrated Planning Tools initiative from the FY 2022-23 Plan to fund larger-scale pilot projects to support a cost-effective and equitable gas transition. The CEC also moved the FY 2024-25 Plan's preliminary research concept titled "Detect and Reduce Fugitive Methane Emissions initiative" to the FY 2023-24 Plan under the Innovative Gas Leakage Monitoring and Mitigation Solutions initiative.

Initiative Theme: Building Decarbonization

Comment Received: ~~see *Written Public Comment Summary,* below.~~
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.

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[81] 2021 SB 100 Joint Agency Report: Achieving 100 Percent Clean Electricity in California: An Initial Assessment. March 2021.

[82] CEC. 2022. GFO-22-304 Assessing the Role of Hydrogen in California's Decarbonizing Electric System. https://www.energy.ca.gov/solicitations/2022-10/gfo-22-304-assessing-role-hydrogen-californias-decarbonizing-electric-system

Written Public Comment Summary and CEC Responses

Initiative Theme: Building Decarbonization

General Comment Received:

Above and beyond the public health aspects of building decarbonization, we support a broader focus on this area, including recommendations to conduct a comprehensive array of commercial, industrial, and residential building decarbonization site pilots at representational scale(s), neighborhood- and community-scale zonal electrification pilots, and/or full gas decommissioning scenarios. Research should consider in-depth study of distribution grid capacity, at-building electrical service capacities and upgrades (including upgrades to the distribution grid), electrification of larger electrical loads within buildings (e.g., HVAC), inclusion of distributed energy resources (solar PV, energy storage, bi-directional electric vehicle charging infrastructure), and grid services provided by coordination between the distribution grid and building energy management systems. Particularly in rural and Tribal areas, building electrification and decarbonization is not yet supported by the contractor ecosystem. Research should be done to improve understanding of the deployment gaps (e.g., skills, product knowledge, access to incentives) that are barriers to contractors and end users conducting building decarbonization projects. Further building decarbonization research should always include an economic impact component to better understand tolerances for disadvantaged communities, particularly low-income participants, in home decarbonization (adopters and non-adopters of home decarbonization solutions).

CEC Response:

Staff are grateful for this compelling suggestion and are working to develop tractable research approaches that better capture the cross-cutting nature of building decarbonization, gas decommissioning, and energy transitions overall. This includes, as DACAG's comment outlines, more fully recognizing the need to negotiate a diversity of geographic, energy infrastructural, technical, socioeconomic, energy user, and supply chain circumstances and their implications with respect to barriers and opportunities for gas decommissioning, as well as pertaining to the distribution of its benefits and potential costs it entails over near and longer terms.

Some elements of this more integrative approach are expected to be reflected in the proposed *Air Pollutant Exposure Assessment* research initiative. Additional elements are anticipated to be covered in the proposed *Targeted Gas System Decommissioning* research initiative, including (1 by selecting diverse pilot decommissioning locations (possibly including a pilot in a tribal or rural area) and deliberately considering the translation from local circumstances to large-scale decommissioning, and (2 by developing data and planning tools that support the more integrative approach that DACAG suggested in its comment, paving a pathway for further coordination across relevant initiatives, programs, and research angles (e.g. technology development, localized needs, and multi-family versus single-family homes). DACAG's suggestions also resonate with recently approved elements of the FY 2022-23 Gas R&D Program Budget Plan, which includes support for integrated planning approaches that "simultaneously address the timing of infrastructure investments and the pragmatics of upgrades. Examples include electrical panel upgrades or workarounds, financing, supply chain and workforce dynamics, and field-vetted replacement technologies and upgrade packages that are attractive to consumers."

While the funding allocated for these activities within the FY 2023-24 proposed initiatives is very limited, the CEC will also take DACAG's comments into consideration in scoping future research, including for FY 2024-25 initiative planning.

Initiative Title: Air Pollutant Exposure Assessment in California Residences

Comment Received:

The DACAG supports research into accelerated building decarbonization, including research on the public health implications of cooking. DACAG recommends including indoor air quality concentrations and health outcomes in the context of building quality, kitchens with and without hoods, and before and after weatherization and ventilation upgrades. They also suggest including single and multi-family homes in disadvantaged communities and assessing the demographics of the populations most vulnerable to indoor air pollution. In addition, they recommend conducting a comprehensive array of commercial, industrial, and residential building decarbonization pilots at a variety of scales, neighborhood- and community-scale zonal electrification pilots, and/or full gas decommissioning scenarios. DACAG further suggests that the research should also include an economic impact component to better understand equity and affordability implications for disadvantaged communities, particularly low-income participants.

CEC Response:

The CEC appreciates DACAG's strong support into research on the public health implications of decarbonizing California's residential kitchens. We concur with DACAG's recommendation to include homes (multi- and single family) in disadvantaged communities and to include an assessment of population demographics of exposed populations. These elements are critical to enable understanding of the magnitude and distribution of public health-related impacts of decarbonization, and our research aims to prioritize them accordingly.

While the Gas R&D funding proposed here is insufficient to both provide a basis for exposure assessment *and* to investigate health outcomes, it will lay a rigorous, empirically grounded foundation for quantitative assessment of exposures to cooking-related indoor air pollutants in California homes, particularly those in multifamily residences. Ongoing and potential future EPIC research efforts are investigating health outcomes associated with electrification. Thus, DACAG's recommendation that CEC develop a basis for assessing health impacts associated with electrification is being addressed. However, given the substantial investment required to achieve these objectives, research supported through other funding streams is needed to complement and build upon the critical foundation laid by Gas R&D-funded research.

Initiative Title: Networked Geothermal District Heating Study

Comments on the Networked Geothermal District Heating Study were received via written public comment in 2024, when the initiative was initially proposed for the FY 2024-25 Gas R&D Budget Plan and added to the updated FY 2023-24 Gas R&D Budget Plan.

Comment Received from SoCalGas: 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. 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. 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:

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.

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.

CEC staff appreciate this feedback and concur that gas utilities could have a positive impact on geothermal district heating.

APPENDIX D:
List of 2022 Gas R&D Events

January 2022:

- Staff Workshop to Discuss Proposed Gas Research Initiatives for FY 2022-23
- Pre-Application Workshop – GFO-21-506 – Integrative Corrosion Control in the Gas System

February 2022:

- Pre-Application Workshop – GFO-21-507 – Targeted Hydrogen Blending in Existing Gas Network for Decarbonization

March 2022:

- Staff Workshop: Quantify Indoor Air Pollutants in Multifamily Homes that Cook with Gas Stoves or Alternatives

June 2022:

- Communities, Equity, and Environmental Workshop Regarding Establishing a Long-Term Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals
- Technology Workshop Regarding Establishing a Long-Term Gas Research Strategy to Achieve Aggressive Statewide Carbon Neutrality Goals
- IEPR Commissioner Workshop on Role of Hydrogen in California's Clean Energy Future

October 2022:

- Pre-Application Workshop – GFO-22-502 – Innovative Hydrogen Refueling Solutions for Heavy Transport

December 2022:

- Webinar on Long-Term Gas Research Strategy Recommendations
- Pre-Application Workshop – GFO-22-503 – Gas Pipeline Safety and Integrity Research to Support Decarbonization
- Inaugural meeting of the California Energy Commission's Healthy, Equitable Energy Transition (HEET) Working Group

APPENDIX E:
FY 2023-24 Gas R&D Equity Framework Topic Definitions

The FY 2023-24 Gas R&D Plan includes the application of the DACAG Equity Framework. The five key equity principles have been adapted to apply to the Gas R&D Program and Electric Program Investment Charge (EPIC Program).

Health and Safety

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

Access and Education

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

Financial Benefits

CEC investments will lead to technological advancements that lead to financial benefits and cost savings while considering affordability and rate impacts. For example, improved energy efficiency and load flexibility will result in electric bill savings; advancements in energy resilience from energy storage technologies will help reduce financial impacts to businesses facing grid reliability issues; and manufacturing advancements will reduce the costs of clean energy technologies. In addition, CEC EPIC funding can expand community investment by attracting additional public and private funding and building capacity for future grant applications and clean energy

project developments CEC recognizes that the value of money varies with income, and EPIC investments will prioritize financial benefits in under resourced communities to improve energy equity.

Economic Development

CEC investments will support economic development by:

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

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

Consumer Protection

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

Direct and Indirect Benefits

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

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

APPENDIX F:
Estimated FY 2023-24 Gas R&D Administration Cost Breakdown

Based on analyses conducted on FY 2022-2023 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	$229,643
Project Planning and Initiation	$504,013
Project Oversight and Governance	$694,580
Stakeholder Communication, Engagement, and Outreach	$116,815
Regulatory Support Compliance	$230,227
Internal Management Coordination	$77,101
Program and Process Coordination and Improvement	$63,106
Administrative Activities	$81,546
Supervision and Personnel	$271,864
Training and Development	$131,105
Total	**$2,400,000**