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CALIFORNIA NATURAL RESOURCES AGENCY

Research and Development Division

STAFF REPORT

Gas Research and Development Program

Proposed Budget Plan for Fiscal Year 2023–24

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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 2023–24. The proposed research and development aligns with the themes of gas leakage mitigation, building decarbonization, targeted gas system decommissioning, and leveraging cost share opportunities. The initiatives support state energy policies and goals, with several initiatives directly benefiting underresourced communities. The proposed research funding for Fiscal Year 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, and a public workshop, among other input received on CEC's gas-related efforts.

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

Keywords: California Energy Commission, California Public Utilities Commission, gas,climate change, 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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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) and other agencies; and stakeholder input. Key policies, plans, and guidance include Executive Order B-55-18, Assembly Bill (AB) 1279 (Muratsuchi, Chapter 337, Statutes of 2022), Integrated Energy Policy Reports, and CPUC decisions and resolutions, among others.

This proposed Fiscal Year (FY) 2023–24 Gas R&D Budget Plan includes R&D funding for four initiatives aligned with four themes (Table ES-1). The proposed R&D serves to support gas leakage reduction, building decarbonization, 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, 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	
Targeted Gas System Decommissioning	Scaled-Up Gas Decommissioning Pilot and Integrated Planning Tools	$2,000,000	
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 Senate Bill 100 (De León, Chapter 312, Statutes of 2018), among others. However, fossil gas use remains significant, and the overall gas demand in California could grow over the next decade in a business-as-usual scenario.[1]

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

Gas R&D Program Background

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

Recognizing the benefit of gas research to Californians, Assembly Bill (AB) 1002 (Wright, Chapter 932, Statutes of 2000) directed the California Public Utilities Commission (CPUC) to add a surcharge on gas consumed in California to fund R&D specific to the gas system. The 2004 CPUC Decision 04-08-010 designated the California Energy Commission (CEC) as the administrator for the Gas R&D Program. The CPUC allocates $24 million annually and defines public interest gas research activities as those "directed towards developing science or technology, and 1) the benefits of which accrue to California citizens, and 2) are not adequately addressed by competitive or regulated entities."[3] The decision also provides direction that R&D projects focus on energy efficiency, renewable technologies, conservation,

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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.

and environmental issues; support state energy policy; offer a reasonable probability of 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 Sente Bill 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). Thislaw authorizes continuous appropriation of funds in the CEC subaccount in the Public Interest Research, Development, and Demonstration Fund to the CEC for its costs of administering the Gas R&D program. While Gas R&D Program funds do not expire, the CEC strives to encumber these funds within two years and complete projects within a total of six years, when possible, which aligns with the original law. The CEC is also required to report to the Legislature on the outcomes, effects, and benefits of the program by October 31 of each year.

The Gas R&D Program has invested in R&D to develop technologies, tools, and strategies that increase energy efficiency, lower energy cost, reduce air pollutants and greenhouse gas (GHG) emissions, and improve the safety of gas infrastructure. Recent program achievements are included in the Gas Research and Development 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, 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 and other agencies; and stakeholder input, 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, stakeholder 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:

- Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), which establishes the state's goal for a 40 percent GHG emissions reduction below 1990 levels by 2030.
- CEC IEPRs, 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 efficiency. Initiative themes of the budget plan also support sets of policies, as described in Appendix A.

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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.

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 2023-2024 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. 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 Assembly Bill 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 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.

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.

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-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.

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, 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.

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

13 Available upon request.

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 (DCAG) will be noticed.[15]

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

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

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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.

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.

Some recent examples of outreach efforts to support diversity and equity commitments include improving the CEC's application and grant management processes to relieve administrative burdens for applicants. This improvement is particularly beneficial for new and underresourced entities. 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 can 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 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 underresourced 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 underresourced 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.

Senate Bill 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 funds 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*

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.

Research and Development 2021 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 Electric Program Investment Charge (EPIC) subject matter expert meeting January 18, 2023.
- Notifying the DACAG of the January 17, 2023, Gas R&D Plan — Stakeholders Workshop and offering the opportunity for public comment.
- 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.

The CEC staff has helped train underresourced 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. The CEC staff is also coordinating additional webinars targeted at local governments and community-based organizations. The CEC staff continues 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 is 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 stakeholders to develop a research portfolio responding to challenges in the gas sector. Examples of annual coordination includes:

- Southern California Gas Company (SoCalGas) Research, Development and Demonstration 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 CEC staff participates in relate to the following topics:

- California's Fifth Climate Change Assessment (led by the California Office of Planning and Research);
- 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);

19 California Energy Commission Energy Research and Development Division. 2020. 2020 *Natural Gas Research and Development Program Annual Report.* California Energy Commission. Publication Number: CEC-500-2020-073.

- 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 GO-Biz);
- 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]).

The CEC also conducted a public workshop January 17, 2023, to present the Proposed FY 2023-2024 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.)

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

Collaborative and Cofunding Opportunities

The CEC engages with a wide range of California stakeholders, including research institutions, governmental agencies, industry, and utility representatives (for example, Pacific Gas and Electric [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 2021–2022 Budget Plan resulted in competitively awarded projects bringing in nearly $8 million in match funds, effectively increasing the program funding level by 30 percent. A total of $1.5 million of these match funds came from IOUs (such as SoCalGas), $1.23 million from community- or publicly funded entities (for example, 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 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.

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

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

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 four initiatives aligned with 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 2024–2025) 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] Assembly Bill 148 (Committee on Budget, Chapter 115, Statutes of 2021) provided the CEC with authority to continuously appropriate gas funds from the Public Interest Energy Research, Development, and Demonstration Fund for administering energy-related programs.[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.

22 $1,175,266 from a cancelled project from the 2016/17 Budget Plan, $1,230,000 from unspent and unencumbered funds from FY 2020–2021 Budget Plan, $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	
Targeted Gas System Decommissioning	Scaled-Up Gas Decommissioning Pilots and Integrated Planning Tools	$2,000,000	
Leveraging Cost Share Opportunities	Federal and Private Cost Share	$5,640,000	$2,405,266
Comprehensive Programmatic Evaluation, Pursuant to 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

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.

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 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

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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.

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.

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 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

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.

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.

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 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

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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.

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

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 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,

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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.

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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.

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.

Expected Initiative Outcomes

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 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

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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.

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

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 by electric counterparts is expected to accelerate over the next few decades and reduce demand for gas.[49] Measurement of nonenergy benefits of cleaner energy technologies inside buildings is important to support and accelerate electrification interventions such as induction stoves.

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

Prior scientific studies, including efforts funded by the CEC,[50] 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.[51]

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."[49] 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 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 2023–2024 Gas R&D Budget Plan proposes an initiative to assess air pollutant exposures in California homes.

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.

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50 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.

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

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.[52]

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 supported by the FY 2021–2022 Gas R&D Plan, which at $2 million is underresourced 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 2021–2022 Gas R&D initiative (solicitation forthcoming) will measure 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 2023–2024 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."[53] 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.

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52 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

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

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 Clean Energy Solutions"). This initiative aims to provide tools for assessing the health benefits of electrification across a range of socioeconomic and demographic variables.[54]

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 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 (CPUC, 2020). 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.[55] 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.[56] Prior research indicates that a managed gas transition is imperative to address issues related to cost and equity.

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

55 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.

56 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.

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 2023–2024 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 2022–2023 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 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.[57] 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.

Investor-owned utilities (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-

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

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).[58]

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 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[59] 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

58 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)59 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.

59 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.

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 promote a future large-scale decommissioning pilot to support a cost-controlled and equitable gas transition.

The pilot projects funded by this initiative will build on existing research on gas decommissioning[60] 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, 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 underresourced 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.

60 PIR-20-008 - Strategic Pathways and Analytics for Tactical Decommissioning (SoCal): available at https://www.energy.ca.gov/filebrowser/download/3511; PIR-20-009 - Strategic Pathways and Analytics for Tactical Decommissioning (NorCal), available at: https://www.energy.ca.gov/filebrowser/download/3496; 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.

It will build on analyses of large-scale pilots as well as ongoing development[61] 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.
- Be designed to reflect emerging understanding about:
    - 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.

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

61 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.

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 will 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[62] 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.

62 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	Econo Develop
1	Gas Leakage Mitigation		Direct Benefits	Direct Benefits	Indirect Benefits	Indire Benef
2	Building Decarbonization		Indirect Benefits	Indirect Benefits	Indirect Benefits	Indire Benef
3	Scaled-Up Decommissioning Pilots and Integrated Planning Tools		Direct Benefits	Direct Benefits	Direct Benefits	Indire Benef
4	Federal and Private Cost Share		Indirect Benefits	Indirect Benefits	Direct Benefits	Indire Benef

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.[63] 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,[64] and final reports for completed projects are published on CEC's publication website.[65]

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

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

65 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
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
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 Costs