PG&E Gas Research, Development and Demonstration

Annual Report 2024

Table of Contents

Innovating for an Affordable, Reliable, and Decarbonized Energy Future 3

Our True North Strategy 4

Innovative approaches to greening the gas supply 5

A comprehensive approach to emissions reductions 8

Leveraging the power of AI to achieve our True North Strategy 9

PG&E's Gas Research, Development, and Demonstration Team 11

RD&D drives innovation 12

Research areas 13

2024 in Review 15

Financial highlights 16

2024 Funding recipients 20

Diversity. Equity. Inclusion. Belonging. 21

Supporting projects that matter 24

Our approach 27

Coworker experience 29

Employee networks 30

Select DEIB milestones 31

Process Used to Select Gas RD&D Projects 33

Structure of PG&E's Gas RD&D Portfolio 38

Investment theme 1: Gas System Integrity 40

Investment theme 2: Decarbonization 48

APPENDICES 53

2024 Policy drivers 54

2024 Alignment with CPUC policies and proceedings 56

CPUC best practices (BP): D.17-06-015 Natural Gas Leak Abatement Program 59

Acronyms, initialisms, and definitions 60

Project summaries: Gas System Integrity 62

Project summaries: Decarbonization 103

MESSAGE FROM THE SENIOR DIRECTOR of Grid Research, Innovation and Development

Energy is a fundamental necessity of modern life. All Californians—regardless of income level—should have access **clean**, **reliable**, and **affordable** energy for heating, cooking, and other essential needs.

At PG&E, we are committed to making energy more accessible and affordable through our support for research, development, and demonstration (RD&D) projects.

We are making great progress.

In collaboration with technology innovators, regulators, scientists, and engineers across California and the nation, our Gas RD&D team **supported 179 projects in 2024**. The projects described in this report are driving real impact—enhancing operational efficiency, reducing emissions, and positioning PG&E to meet the needs of a decarbonized energy system.

Throughout this report, we share with you the results of our team's extraordinary efforts to develop and deploy breakthrough technologies and processes to improve gas system performance, as measured in public and worker safety, cost effectiveness, environmental impact, regulatory compliance, and customer satisfaction.

We are particularly excited about the growing role of artificial intelligence—AI— in revolutionizing our energy system. In 2024, our Gas RD&D team began to explore ways to integrate AI into the projects that they support with time, resources, and funding.

Moving forward, we plan to expand those efforts because we believe that AI can help us predict maintenance needs, optimize gas distribution, and reduce system losses—improving reliability while lowering operational costs. These savings will directly benefit customers and help keep energy affordable.

By working together with regulators, researchers, and industry partners to support this and other important RD&D work, we believe we can unlock solutions that make clean, low-cost energy a reality for all.

Quinn Nakayama
Senior Director
Grid Research, Innovation and Development

INNOVATING FOR AN AFFORDABLE, RELIABLE, AND DECARBONIZED ENERGY FUTURE

Our True North Strategy

PG&E's **True North Strategy** (TNS) is our 10-year enterprise transformation strategy, guiding us toward a future where we play a pivotal role in California's transition to a net zero emissions, climate-resilient future.

Our strategy is rooted in the belief that PG&E has a responsibility to build a safer, better future, contributing to both environmental sustainability and community prosperity.

TNS directs the entire company to fulfill our commitments to people, planet, and prosperity. It focuses on three key areas:

- Rebuilding trust by delivering affordable energy and excellent service to customers
- Designing a decarbonized, safe, and reliable energy system
- Building strong foundational capabilities to enable these outcomes

Now in its fourth year, TNS drives long-term strategic thinking while maintaining a sharp focus on near-term priorities across Customers, Energy System, and Foundational Capabilities.

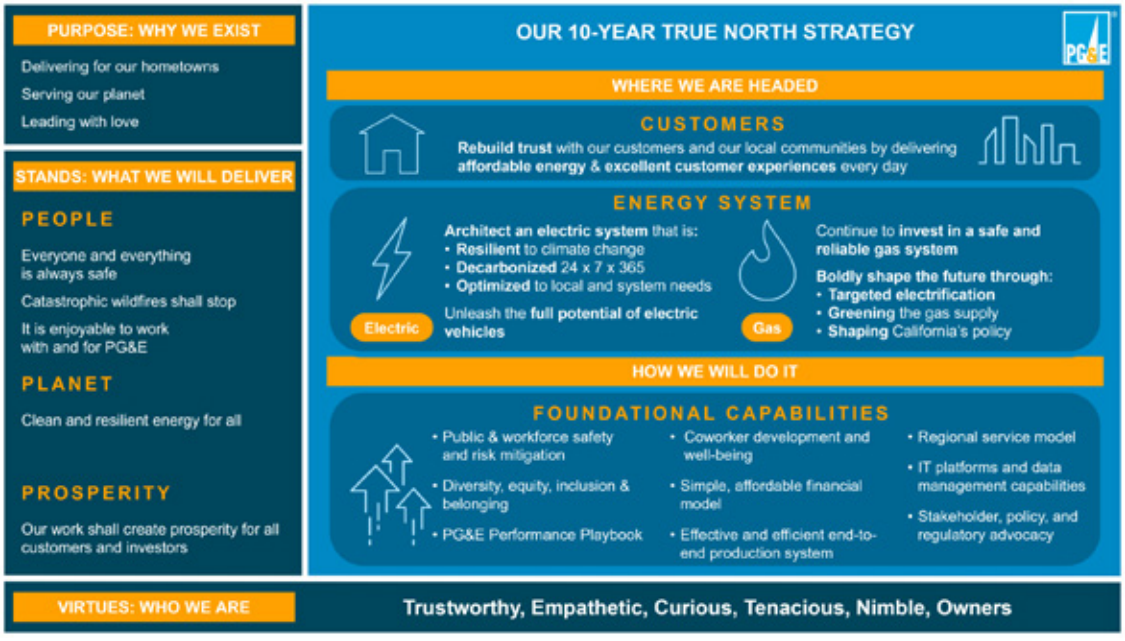


Figure 1: PG&E's 10-year True North Strategy focuses on rebuilding trust, decarbonization, and building strong foundational capabilities to enable these outcomes.

Innovative approaches to greening the gas supply

PG&E owns and operates one of the nation's largest natural gas systems, comprising more than 50,000 miles of combined transmission and distribution pipeline that serves approximately 4.5 million customer accounts.

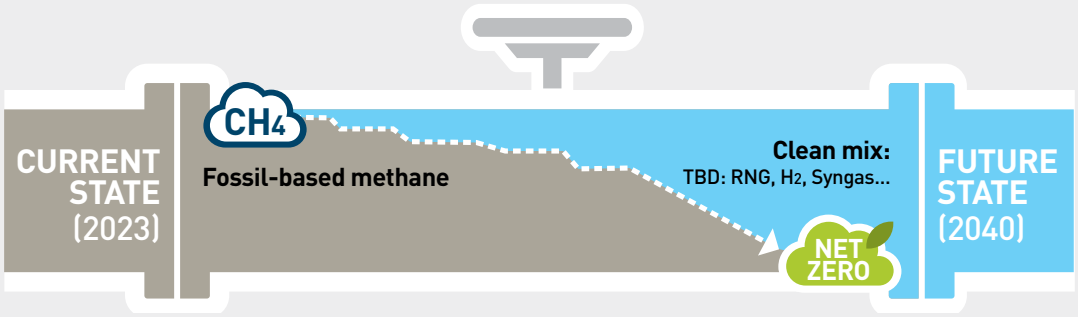


Figure 2: In the ongoing energy transition, PG&E envisions reducing the role of methane in its portfolio and increasing amounts of clean renewable natural gas, syngas, and hydrogen.

Today, methane represents nearly 100% of the 895,520 million standard cubic feet of annual throughput delivered by our system.

In alignment with California environmental policy, PG&E has committed to achieving a net-zero energy system by 2040—five years ahead of California's current carbon neutrality goal. Achieving this ambitious goal will be challenging.

We need to adapt to expected reductions in demand for fossil-based natural gas while integrating cleaner fuels—**renewable natural gas (RNG)**, **syngas**, and **hydrogen**—into our gas system and continuing to provide our ratepayers with safe, reliable, and affordable service.

PG&E has already made great strides toward this goal.

In June 2022, PG&E submitted its annual emissions data to the California Public Utilities Commission (CPUC). Using 2015 emissions levels as a baseline value, the data demonstrated that PG&E had achieved **38% emissions reductions by the end of reporting year (RY) 2023**.

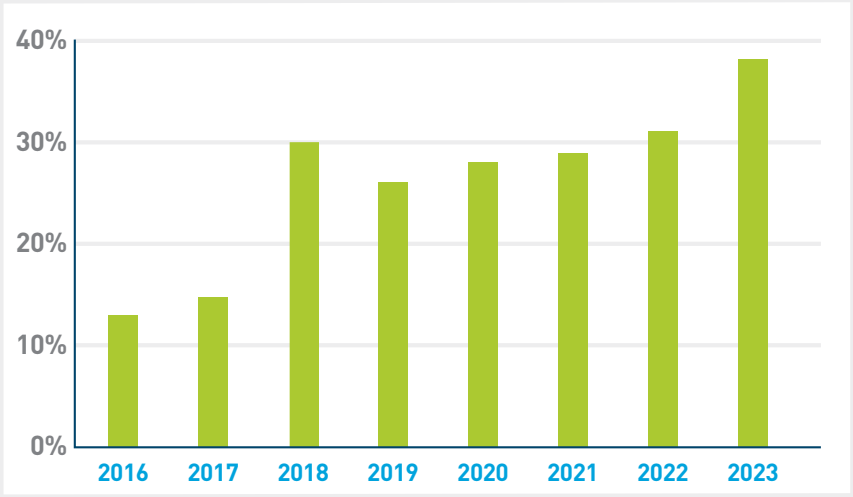
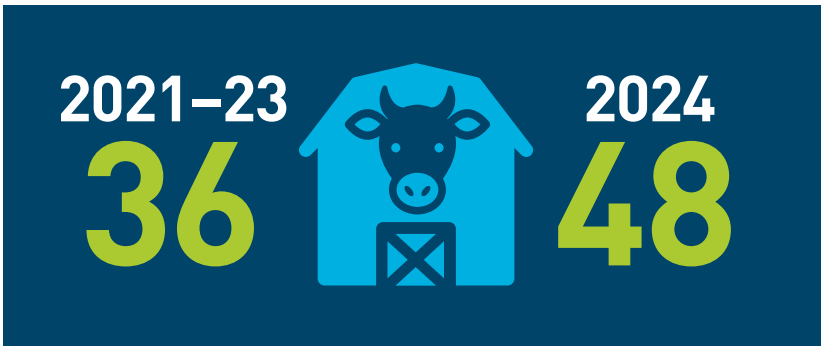


Figure 3: At the end of RY 2023, PG&E had achieved 38% emissions reductions in comparison to baseline year 2015.

In late 2023, PG&E launched an initiative to purchase California-produced RNG for its natural gas customers, **the first step in a plan to procure RNG to serve 15% of its residential and commercial demand by 2030**.

RNG from dairies



Between 2021 and 2023, PG&E began accepting RNG from 36 dairies across its service territory via seven interconnections with its gas infrastructure. By the end of 2024, that number had grown to 48.

A comprehensive approach to emissions reductions

PG&E's Gas Operations and Engineering teams took a comprehensive approach to reducing emissions from the natural gas system, including:[1]

- Enhancing the leak survey program that now assesses more than 42,000 miles of natural gas distribution pipeline every three years versus the previous every-five-years rotation.
- Enhancing the PG&E Super Emitter Program, which applies advanced leak detection technologies to accelerate detection and repair of Super Emitters (SE) above a given threshold. In 2024, we reduced the SE threshold from 7 to 6 standard cubic feet per hour (scfh).
- Utilizing tools and methods such as cross-compression, drafting, flaring, and project bundling to minimize emissions during transmission pipeline maintenance, repair, or replacement projects.
- Replacing more than 100 pneumatic controllers at transmission metering and regulating (M&R) stations, compressor stations and natural gas storage facilities.
- Performing quarterly leak surveys at compressor stations and natural gas storage facilities.
- Piloting the feasibility of compression tape to repair meter set leaks faster.

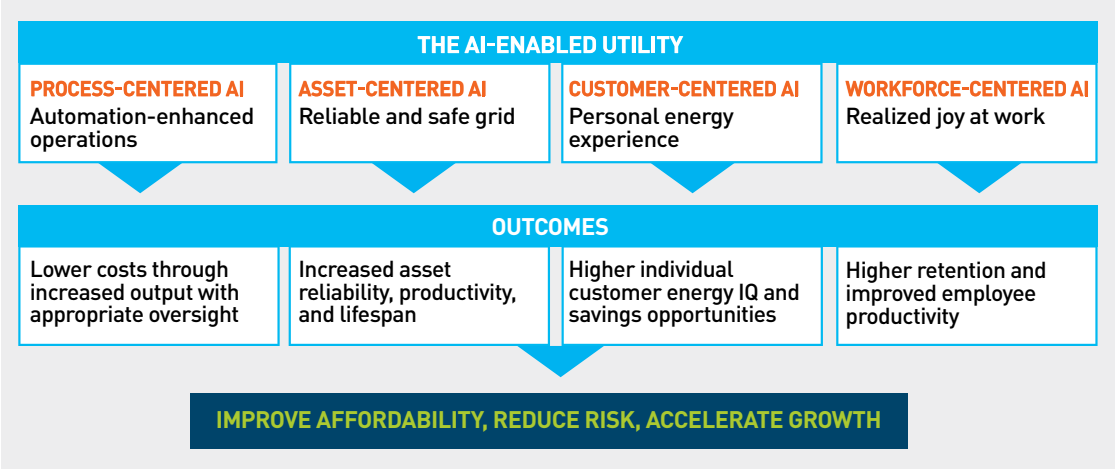
[1]investor.pgecorp.com/news-events/press-releases/press-release-details/2023/PGE-Reduces-Emissions-from-Gas-Pipelines-by-More-than-20/default.aspx

Leveraging the power of AI to achieve our True North Strategy

In pursuit of our TNS goals, PG&E has embarked on a transformative journey to reimagine the way we deliver energy to our customers.

We believe that artificial intelligence (AI) can play a crucial role in facilitating this journey and achieving our TNS. While we have already applied machine learning to mitigate wildfire risks and enhance operations, this marks the first time we are holistically exploring the full potential of AI across our entire system.

Our goal is to make this AI-enabled utility a reality, enabling PG&E to **reduce risks**, **accelerate growth**, and **deliver affordable energy** by generating efficiencies. This ambitious vision involves leveraging AI responsibly to build the energy system of the future, one that is safe, clean, and affordable.



Our investments in building this future will be driven by our True North Strategy goals and will align to the four key pillars depicted above: **Process**, **Asset**, **Customer**, and **Workforce**. These pillars touch all facets of our operations, from customer interactions to internal processes and everything in between. While each pillar delivers unique benefits, they all share a common goal: enhancing affordability and safety.

In 2024, our Gas RD&D team began to explore ways to integrate AI into the projects that they support with time, resources, and funding. Moving forward, **we plan to expand those efforts because we believe that AI can help us predict potential pipeline failures before they occur**, identify defects that might be missed by human inspectors, and prevent leaks and other issues that could lead to environmental and economic consequences—improving reliability while lowering operational costs. These savings will directly benefit customers and help keep energy affordable.

PG&E'S GAS RESEARCH, DEVELOPMENT, AND DEMONSTRATION TEAM

RD&D drives innovation

To bridge the gap between where we are today and the ambitious future that we envision requires research, development, and demonstration.

Our nation's natural gas systems were designed for a world powered centrally by fossil fuels in which supply and demand evolved predictably over time. Today's utility operating environment is changing rapidly and less predictably, placing increasing strain on systems that were designed for a fundamentally different world.

In response to these challenges, PG&E initiated its Gas RD&D team. Composed of energy industry professionals and engineers, Gas RD&D seeks to increase the safety, affordability, and reliability of the gas system, reduce emissions, and future-proof the gas system for the migration to cleaner fuels.

Since 2013, the Gas RD&D team has focused on the development and deployment of breakthrough technologies and processes to improve gas system performance as measured in public and worker safety, customer satisfaction, cost effectiveness, environmental impact, regulatory compliance, and communication.

To optimize its efforts, Gas RD&D leverages collaborative networks and research consortia such as the Pipeline Research Council International (PRCI), PRCI's Emerging Fuels Institute (EFI), NYSEARCH (a research suborganization with the Northeast Gas Association (NGA)), and GTI Energy's two research subgroups, Operations Technology Development (OTD) and Utilization Technology Development (UTD). The Gas RD&D team also participates in ad-hoc joint industry initiatives with other gas utilities or pipeline operators.

Research areas

In 2024, PG&E Gas RD&D invested time, technical resources, and **$965,359 in 179 projects across two investment themes: Gas System Integrity** and **Decarbonization**.

INVESTMENT THEME 1: Gas System Integrity

In this theme, we seek to develop or advance technologies that, if deployed widely, could improve gas system integrity and reduce methane emissions. Gas System Integrity projects develop and advance solutions that could help automate, optimize, and better target existing processes based on a more comprehensive and real-time understanding of conditions across the system.

If deployed widely, these technologies could help proactively address developing challenges in real time and efficiently direct resources based on risk level and other factors, minimizing the need for frequent systemwide inspections. This approach supports the safe and reliable delivery of energy across the system, while reducing emissions and lowering unitized costs of work—something that improves affordability for all customers, including those from Environmental and Social Justice (ESJ) communities.

Projects in this theme are grouped into six initiatives:

- Geohazard risk management
- Compliance with new regulations
- Storage wells
- Advanced methane leak detection
- Revised emission calculation methodologies
- Efficient methane leak repair

INVESTMENT THEME 2: Decarbonization

In this theme, the Gas RD&D group funds projects that develop or advance technologies that, if deployed widely, would decarbonize the gas system.

Such projects include those that conduct foundational research that better informs the industry's understanding of the challenges and impacts of integrating cleaner fuels into existing pipelines and system assets, as well as into customer applications and end uses.

Decarbonizing the gas system is core to PG&E's True North Strategy, as well as supporting the achievement of broader decarbonization goals at state and federal levels; however, research continues about what this transition will look like at scale and how this transition will occur.

While it is widely accepted that hydrogen and other clean alternatives will likely be important fuel sources in the future, there is little certainty across the broader utility industry about exactly how these emerging fuels will be utilized in the future and how existing infrastructure and customer end uses will need to adapt to accommodate the switch from fossil-based natural gas. Foundational R&D and earlier stage research is needed. As a better understanding of cleaner alternative fuels emerges, their interaction with and impact on current system components and infrastructure and other operational considerations will help to inform the path towards decarbonizing the gas supply.

Projects in this theme focus on transitioning to cleaner energy sources, enhancing energy efficiency, and integrating innovative technologies.

Projects in this theme are grouped into two initiatives:

- Impact of hydrogen
- Integrating cleaner fuels

2024 IN REVIEW

Financial highlights

2024 Funds expended

In 2024, PG&E's Gas RD&D team provided time, resources, and $965,359 to 179 projects across its **two investment themes**.

FUNDING CATEGORY	2024 ACTUALS
Gas System Integrity	$773,662
Decarbonization	$191,696
SUBTOTAL	**$965,359**
Management and Administration	$898,280
TOTAL	**$1,863,639**

Per guidance from the CPUC and to increase transparency, Gas RD&D staff further tracked administrative spending across **12 activity categories**.[2]

ACTIVITIES CATEGORY	ACTIVITY TOTALS
Administrative Activities	**$194,826**
Intellectual Property Coordination	**$0**
Internal Management Coordination	**$1,011**
Investment Plan Development	**$115,375**
Post-Initiation Vendor Sourcing	**$18,840**
Program and Process Coordination Improvements	**$3,032**
Project Initiation	**$3,609**
Project Oversight and Governance	**$78,400**
Project Planning	**$46,031**
Regulatory Support and Compliance	**$278,651**
Stakeholder Comms Engage Outreach	**$107,254**
Tech Implementation and Knowledge Transfer	**$51,251**
TOTAL	**$898,280**

[2]Advice 6478-E Joint EPIC Administrator Advice Letter on Administrative Costs found at pge.com/tariffs/assets/pdf/adviceletter/ELEC_6478-E.pdf

2024 Leveraged funding

Collectively, these 179 projects leveraged significant co-funding from private industry, the California Energy Commission (CEC), the US Department of Energy (DOE), the National Science Foundation (NSF), national laboratories, and industry research consortia, including NYSEARCH/NGA, PRCI, EFI, OTD, and UTD.

On a portfolio level, the total value of the projects supported by Gas RD&D in 2024 equaled **$161,181,815**. The total value of PG&E's contribution to these projects over their collective lifetimes is **$7,020,119**, which was matched by **$154,161,696** in co-funding from project partners. Thus, **on average, every dollar of Gas RD&D funding expended on projects is matched by $22 of funding from other sources**—many of which bring out-of-state and federal funds into California, to the benefit of our customers.

	2024 Actual Spend	Total PG&E Budget	Co-Funding	Total Value of Projects	Leverage Ratio
Gas System Integrity	$773,662	$3,878,583	$35,447,924	$39,326,507	9
Decarbonization	$191,696	$3,141,536	$118,713,772	$121,855,308	38
TOTAL	**$965,359**	**$7,020,119**	**$154,161,696**	**$161,181,815**	22

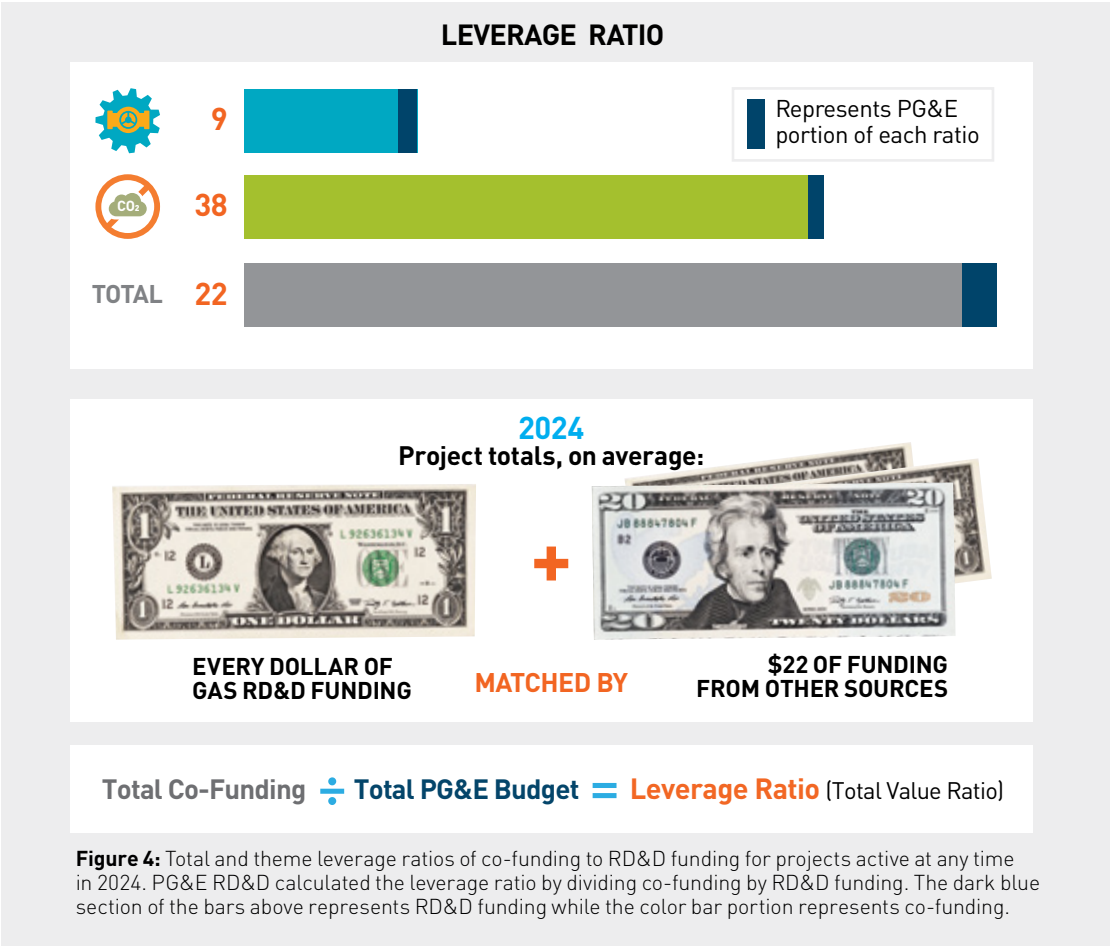


Figure 4: Total and theme leverage ratios of co-funding to RD&D funding for projects active at any time in 2024. PG&E RD&D calculated the leverage ratio by dividing co-funding by RD&D funding. The dark blue section of the bars above represents RD&D funding while the color bar portion represents co-funding.

Some of this leveraged funding included **$70,137,396 in grant funding** from a variety of agencies, including the CEC, the Pipeline and Hazardous Materials Safety Administration (PHMSA), DOE and NSF. In 2024, projects supported by PG&E's Gas RD&D were matched by **$2,340,157 in co-funding from public agencies**.

LEAD INVESTIGATOR	RESEARCH THEME	PG&E FUNDING COMMITTED	FUNDING AWARDED	AGENCY
UTD	Decarbonization	$120,000	$404,000	DOE
UTD	Decarbonization	$70,000	$1,400,000	CEC
UTD	Decarbonization	$144,712	$1,400,000	CEC
UTD	Decarbonization	$153,200	$100,000	DOE
UTD	Decarbonization	$29,167	$2,599,733	DOE
UTD	Decarbonization	$8,333	$300,000	DOE
UTD	Decarbonization	$58,000	$2,200,000	DOE
UTD	Decarbonization	$50,000	$2,000,000	CEC
UTD, CEC	Decarbonization	$71,123	$2,735,000	CEC
UTD	Decarbonization	$37,500	$3,800,000	DOE
UTD	Decarbonization	$37,500	$4,000,000	DOE
UTD	Decarbonization	$42,691	$3,300,000	DOE
UTD	Decarbonization	$87,000	$5,500,000	CEC
OTD	Gas System Integrity	$350,000	$1,000,000	PHMSA
OTD	Gas System Integrity	$7,000	$1,056,000	CEC
OTD, HyBlend	Decarbonization	$150,000	$10,000,000	DOE
OTD	Gas System Integrity	$0	$383,725	PHMSA
OTD	Decarbonization	$50,000	$1,700,000	DOE
OTD	Gas System Integrity	$129,060	$1,500,000	DOE
OTD	Gas System Integrity	$12,554	$1,821,631	CEC
OTD	Gas System Integrity	$45,000	$1,738,436	CEC
Brimstone	Decarbonization	$25,000	$500,000	DOE
GTI Energy	Decarbonization	$0	$3,999,971	CEC
CEC	Decarbonization	$50,000	$1,770,000	CEC
CEC	Decarbonization	$0	$5,658,000	CEC
GTI Energy	Decarbonization	$37,500	$800,000	DOE
Scripps	Gas System Integrity	$0	$1,363,550	CEC
CEC	Gas System Integrity	$440,000	$1,500,000	CEC
PHMSA	Decarbonization	$0	$1,241,000	PHMSA
NYSEARCH	Gas System Integrity	$49,610	$427,052	PHMSA
UC Berkeley, LBNL	Decarbonization	$0	$1,500,000	NSF
Eagle Rock Analytics	Gas System Integrity	$0	$1,000,704	CEC
PHMSA, PRCI	Gas System Integrity	$85,200	$788,594	PHMSA
	TOTAL	**$2,340,157**	**$70,137,396**	

Table 1: Grant funding awarded to projects supported by PG&E's Gas RD&D group and starting in 2024.

Of the 179 projects that PG&E's Gas RD&D group supported in 2024, 159 of those projects were led by four research consortia: UTD, OTD, NYSEARCH/NGA, and PRCI.

For those projects supported by OTD and UTD, PG&E did not provide direct funding. Instead, PG&E paid annual dues and then determined how these dues were allocated across projects. For projects led by the other consortia and research and development (R&D) groups, PG&E paid annual dues and/or paid additional funding in support of specific projects.

FUNDING CATEGORY	2024 DUES
Colorado State University—METEC	$10,000
NYSEARCH Membership	$76,500
OTD Membership	$751,864
PRCI Membership	$161,316
PRCI Emerging Fuels Institute	$100,000
UTD Membership	$350,000
TOTAL	**$1,449,680**

2024 Funding recipients

- Acuren
- Ballard Marine Construction
- BLV Tech
- Brimstone
- California Energy Commission
- Campos Engineering
- DNV
- Eagle Rock Analytics, Inc.
- EMPIT
- G4 Insights Inc.
- GTI Energy
- HyBlend
- Jomar Valve
- Lawrence Berkeley National Laboratory
- NYSEARCH
- OTD
- Paulsson, Inc.
- Pipeline and Hazardous Materials Safety Administration
- PRCI
- QLM Technology Ltd.
- ROSEN Group
- SENSIT Technologies
- Scripps Research Institute
- University of California, Berkeley
- University of California, Riverside
- UTD
- White River Technologies

DIVERSITY. EQUITY. INCLUSION. BELONGING.

Diversity. Equity. Inclusion. Belonging.

PG&E is committed to fostering a culture where **diversity**, **equity**, **inclusion**, and **belonging** (DEIB) are fundamental to our work. We also remain focused on representing the broad diversity of the communities we serve. The Gas RD&D group takes part in many of PG&E's companywide initiatives and factors in these four DEIB principles when selecting projects and technologies to fund. Specifically, this includes assessing impacts to ESJ communities.

Such an approach is critical today as California makes bold strides toward carbon neutrality by 2045, in large part through widespread electrification of transportation, residential and commercial buildings, power generation, and industry. In this environment, customer demand for fossil-based natural gas is projected to gradually decline. At these lower volumes, however, the cost to operate and maintain the gas grid will not see a corresponding drop. As a result, we can envision a system supported more and more by those who do not have the resources to transition to electricity.

WHAT IS AN ENVIRONMENTAL AND SOCIAL JUSTICE COMMUNITY?

ENVIRONMENTAL and SOCIAL JUSTICE

To guide its ESJ efforts, PG&E has adopted the CPUC's definition of an ESJ community as one where residents are:[3]

- Predominantly **people of color** or **low-income**
- **Underrepresented** in the policy setting or decision-making process
- Subject to a disproportionate impact from one or more **environmental hazards**
- Likely to experience **disparate implementation of environmental regulations and socio-economic investments** in their communities

These communities may also include:

- **Disadvantaged communities**[4]
- **All Tribal lands**
- Low-income households (defined as household incomes **below 80 percent** of the area median income)
- Low-income census tracts (defined as census tracts where aggregated household incomes are **less than 80 percent of area or state median income**)

To ensure that the energy transition does not leave these ratepayers behind, PG&E is actively seeking to evolve the gas system into an affordable, safe, and reliable net-zero energy delivery platform that helps California achieve its ambitious climate goals while avoiding or mitigating any adverse impacts—including rising energy costs or reduced reliability—on ESJ communities.

[3] cpuc.ca.gov/news-and-updates/newsroom/environmental-and-social-justice-action-plan
[4] oehha.ca.gov/calenviroscreen/report/calenviroscreen-40

Supporting projects that matter

PG&E Gas RD&D supports projects seeking to increase the efficiency of pipeline operations and maintenance activities, reduce emissions, and future-proof the gas system for the migration to cleaner fuels.

Recognizing the short-term, negative impacts that the energy transition may have on ESJ communities and people underrepresented in the sciences, technology, engineering, and mathematics (STEM), we evaluate every project we consider for its potential to benefit these groups.

Examples of how we do or plan to do this include:

- **Siting RD&D projects** with no potential short-term negative environmental impacts in ESJ communities. In 2024, PG&E's Gas RD&D group supported 32 RD&D projects located in ESJ communities.
- **Prioritizing projects** whose principal investigator or lead researchers are from an ESJ community or an underrepresented group.
- **Collaborating** with minority serving institutions.
- **Supporting technologies** that, if fully commercialized, could reduce emissions, improve air quality, and increase the reliability, safety, and affordability of energy in ESJ communities.

In addition to these targeted efforts, Gas RD&D staff leverage many of PG&E's ongoing DEIB efforts.

(see pages 29 and 30)

PG&E leads the industry

For more than two decades, PG&E has led the industry in DEIB:

Transparency:

Since 2023: We have published our **workforce demographics**.

Diversity:

PG&E Corporation is **ONE** of **EIGHT** **Fortune 500** utilities led by a **FEMALE CEO**.

Leadership:

Since 2006: DEIB principles have served as a foundation of our leadership development, onboarding and training.

Community:

PG&E Corporation has maintained **Employee Networks for 50 years** that continue to be at the forefront of our efforts.

Our workforce offers diverse perspectives

50% ETHNIC MINORITIES

26% WOMEN

7% MILITARY VETERANS

7% INDIVIDUALS WITH DISABILITIES

10% OTHER

Our coworkers represent five generations, most of whom are Millennials, Gen X, and Boomers*

47% MILLENNIALS

38% GEN X

12% BOOMERS

3% OTHER

Racial and gender diversity is reflected among our workforce**

MIDDLE MANAGEMENT:

39% MINORITIES

34% WOMEN

EXECUTIVES AND SENIOR MANAGEMENT:

33% MINORITIES

42% WOMEN

EXECUTIVE OFFICERS:

50% MINORITIES

50% WOMEN

*Generational data refers to "Millennials" for individuals born between 1981 and 1996, "Gen X" between 1965 and 1980, and "Boomers" between 1946 and 1964.

**Women are included in both categories.

Our approach

PG&E's efforts to foster a DEIB culture and workforce are led by the Vice President, Chief Talent, Culture, and Inclusion Officer, with support from the senior leadership team.

The People and Compensation Committee of PG&E Corporation's Board of Directors reviews our DEIB practices and progress. This oversight helps ensure that our principles are embedded throughout the lifecycle of our talent management programs.

Key elements of our approach include engaging coworkers from day one, emphasizing the importance of DEIB through our onboarding and leadership development courses, and mentoring and targeted coworker development for diverse talent.

35.64%
TOTAL PROCUREMENT SPEND

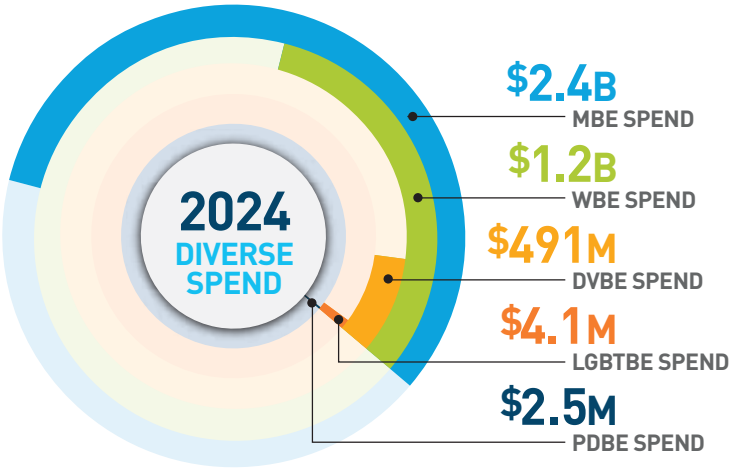
DIVERSE SPEND IN 2024: $4.09 billion

596 ACTIVE DIVERSE SUPPLIERS

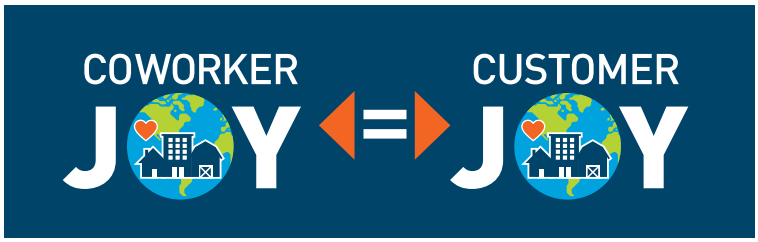
Supplier Diversity[5]

PG&E achieved **$4.09 billion in diversity spend** or **35.64% of our net procurement**. 2024 marked 19 consecutive years of exceeding the 21.50% CPUC goal and the sixth consecutive year of PG&E achieving over $3 billion in spending with diverse suppliers.

PG&E is committed to diversity in our supply chain. PG&E's spending with diverse suppliers not only provides a positive economic impact, but also helps the company live our purpose, virtues and stands which include delivering for our hometowns.



[5]pge.com/assets/pge/docs/about/doing-business-with-pge/supply-chain-responsibility-annual-report.pdf



Coworker experience

From day one at PG&E, we ground all coworkers in our commitment to and definitions of DEIB at new hire orientation.

In 2022, we added the term "belonging" to our approach to describe our values more fully:

Diversity is characterized by all the ways in which we are different. It's present in our job functions, work styles, experiences, and ideas. Diversity cultivates new perspectives and innovation, which enable us to better serve our customers, fellow coworkers, and shareholders.

Equity seeks to provide fair treatment, access, opportunity, and advancement for all people, while at the same time identifying and eliminating barriers that have prevented the full participation of some groups.

Inclusion is the process of leveraging the power of our coworkers' individual uniqueness to achieve our business strategies and goals, be better corporate citizens, and lead the industry.

Belonging means coworkers feel seen for their unique contributions, connected to coworkers and leaders, supported in their daily work and professional growth, and proud of our purpose, virtues, and stands.

Employee networks

PG&E's Employee Networks date back five decades and, today, consist of Employee Resource Groups (ERGs) and Engineering Network Groups (ENGs) that help promote our business objectives and support a culture of DEIB by:

Supporting an environment of inclusion and belonging that values, recognizes, and acknowledges diversity in our workforce.

Promoting positive relationships with the hometowns and customers we serve.

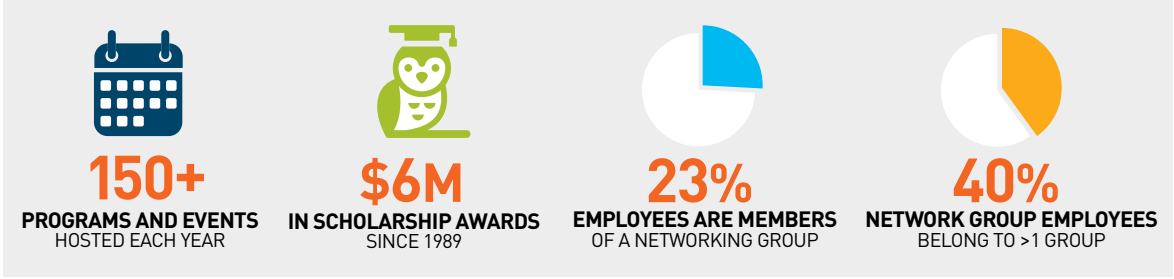
These networks help create an environment where every coworker can feel welcome and contribute to our overall business success. They assist in welcoming and mentoring new and existing coworkers, provide professional and career workshops, host social networking events, help recruit our future workforce, and offer community support through volunteerism, scholarships, customer education, and an environment for collaboration.

ERG and ENG members come from every level and job function and participate across 27 chapters throughout our service area.

40% of all ERG and ENG members belong to more than one group, providing opportunities for allyship among the different groups and communities represented. Nearly half of PG&E's officers are executive sponsors, each of whom serves as an advisor and mentor providing strategic guidance to align strategy and action plans to the needs of the business.

Each year, our ERGs and ENGs support community organizations through charitable contributions and volunteerism. While these groups began as grassroots organizations, they've evolved into groups that create awareness and educate our workforce about culture and experiences. In turn, they also serve as ambassadors for our DEIB efforts at PG&E.

PG&E EMPLOYEE NETWORKS:



Select DEIB milestones[6]

Select awards

Nuclear Energy Institute
Top Innovative Practice

Association of Edison Illuminating Companies
AEIC Achievement Award

Edison Electric Institute
- Business Diversity Innovation Award
- Emergency Recovery Award
- Outstanding Customer Engagement

[6]2024 data was not yet available at the time of publication

Recognition

Black Enterprise
One of the Best Companies for Diversity, Equity and Inclusion

Time Magazine
One of the World's Best Companies

Women's Business Enterprises
One of America's Top Corporations

DEI BEST PLACE TO WORK FOR DISABILITY INCLUSION 2023
100 DISABILITY EQUALITY INDEX
PG&E scored 100% for 9 straight years*

U.S. Department of Labor
- Recipient of the **HIRE Vets** Gold Medallion
- One of the top employers for veterans

Newsweek Greatest Workplaces
- America's Greatest Workplaces
- America's Greatest Workplaces for Diversity
- America's Greatest Workplaces for Parents and Families

PG&E contributed **$22.6 million** to charitable organizations through its **Better Together Giving Program**, designed to help address critical social, educational, and environmental challenges in the communities it serves.

Forbes Best Employers
- America's Best Large Employers
- Best Employers for New Grads
- America's Best Employers for Diversity

PG&E actively worked to strengthen its engagement with **Tribal governments to better serve their communities**, while also training coworkers on Tribal cultural awareness.

PG&E PowerPathway™

Graduated its 16th year of **PowerPathway™**, an innovative program that helps people, including women and military veterans, prepare for high demand jobs in the utility and energy industry. There have been more than 1,240 graduates since the program's inception in 2008.

Campaign for the Community

PG&E contributed **$8.8 million** in coworker, retiree, and matching gifts to nearly 5,000 organizations through its annual **Campaign for the Community**.

*This index is compiled by Disability: IN and the American Association of People with Disabilities.

PROCESS USED TO SELECT GAS RD&D PROJECTS

Figure 5: PG&E's 2024 R&D Strategy Report includes 22 problem statements directly related to gas RD&D.

To select the projects and technologies that receive funding, the Gas RD&D team has conducted and continues to conduct a variety of activities.

In November 2022, PG&E reorganized its electric and gas R&D efforts and began work on its *2023 R&D Strategy Report*. As a part of this process, PG&E's R&D teams worked closely with company operations staff to conduct a gap analysis and identify key technology gaps—including 32 directly related to gas RD&D—that stood in the way of PG&E achieving its objectives for its energy system.

In 2024, PG&E updated the report,[7] detailing **67 problem statements**, including 50 that appeared in the *2023 R&D Strategy Report*. In addition to updating and refining these 50 problem statements, PG&E also added **17 new problem statements** that reflect emerging areas for R&D across its energy system.

[7]pge.com/assets/pge/docs/about/pge-systems/pge-rd-strategy-report-2024.pdf

The 2024 R&D Strategy Report includes 22 problem statements directly related to gas RD&D, as well as an additional six related to the role of RNG and clean hydrogen in net-zero energy systems.

To address these problem statements, Gas RD&D has organized its efforts into two main investment themes—**Gas System Integrity** and **Decarbonization**. These high-level themes and associated technology gaps serve as the framework that Gas RD&D staff use when identifying potential projects to support, evaluating them, and making final selections.

Gas System Integrity problem statements

- Improving pipeline crack assessment technologies
- Verifying material properties for existing pipeline cost-effectively
- Reducing cost of well inspection and monitoring
- Enabling corrosion inspections for difficult to access spans
- Streamlining aboveground leak repairs
- Reducing the cost of T&D leak detection
- Reducing false positives on leak detection surveys
- Enabling remote meter set corrosion inspections
- Improving accuracy of well life estimations
- Increasing accuracy of geohazard risk assessment and monitoring
- Improving pipeline locating technologies
- Reducing cost of pipeline integrity inspection and monitoring
- Enhancing scalability of aboveground leak detection and monitoring
- Improving emissions calculation methodologies
- Eliminating methane emissions from transmission pipeline blowdowns

Decarbonization problem statements

- Understanding risks and impacts from trace RNG chemicals
- Increasing availability of operational data for hydrogen effects on gas system
- Mitigating hydrogen embrittlement at scale
- Understanding safety risks of hydrogen blend leaks
- Improving metering accuracy with hydrogen mixtures
- Ensuring compatibility of customer applications with mixed gas
- Reducing uncertainty of storage facility performance for hydrogen blends
- Eliminating gas appliance combustion emissions
- Facilitating cost-effective and safe deblending
- Enhancing gas quality analysis
- Reducing costs of interconnection skids
- Identifying cost-effective and scalable sources for RNG production
- Eliminating 100% of carbon emissions cost-effectively

Prior to initiating new projects, the Gas RD&D team leads an ideation effort to define and select ideal projects for its portfolio. The Gas RD&D team first assesses strategic and industry-related opportunities and gaps. Then, the team develops a plan for ideation in coordination with "top-down" guidance, which includes direction to prioritize projects that address identified technology gaps and contribute to the achievement of California energy polices and company strategies.

Next, the Gas RD&D team informally reaches out to internal and external stakeholders to gather project ideas in line with the company's overall TNS and climate strategies. Throughout the year, vendors, industry collaborators, and research consortia periodically submit projects for consideration. The team then collectively defines, assesses, and selects project ideas to advance. As part of this assessment, the Gas RD&D team may conduct benchmarking, industry outreach, and vetting with internal/external entities.

Once the Gas RD&D team has tentatively identified the projects it wishes to support, it asks project teams to develop a project proposal summary that will be used to review and approve the project before advancing it to the planning phase. This summary includes the development of initial scope, schedule, and budget estimates.

The summary goes through multiple rounds of review, each of which results in one of three decisions: approved to move to next round of review, refine and bring back for further review, or defer for potential future consideration.

Once all reviews and approvals are complete, Gas RD&D staff communicate the approval to the project team.

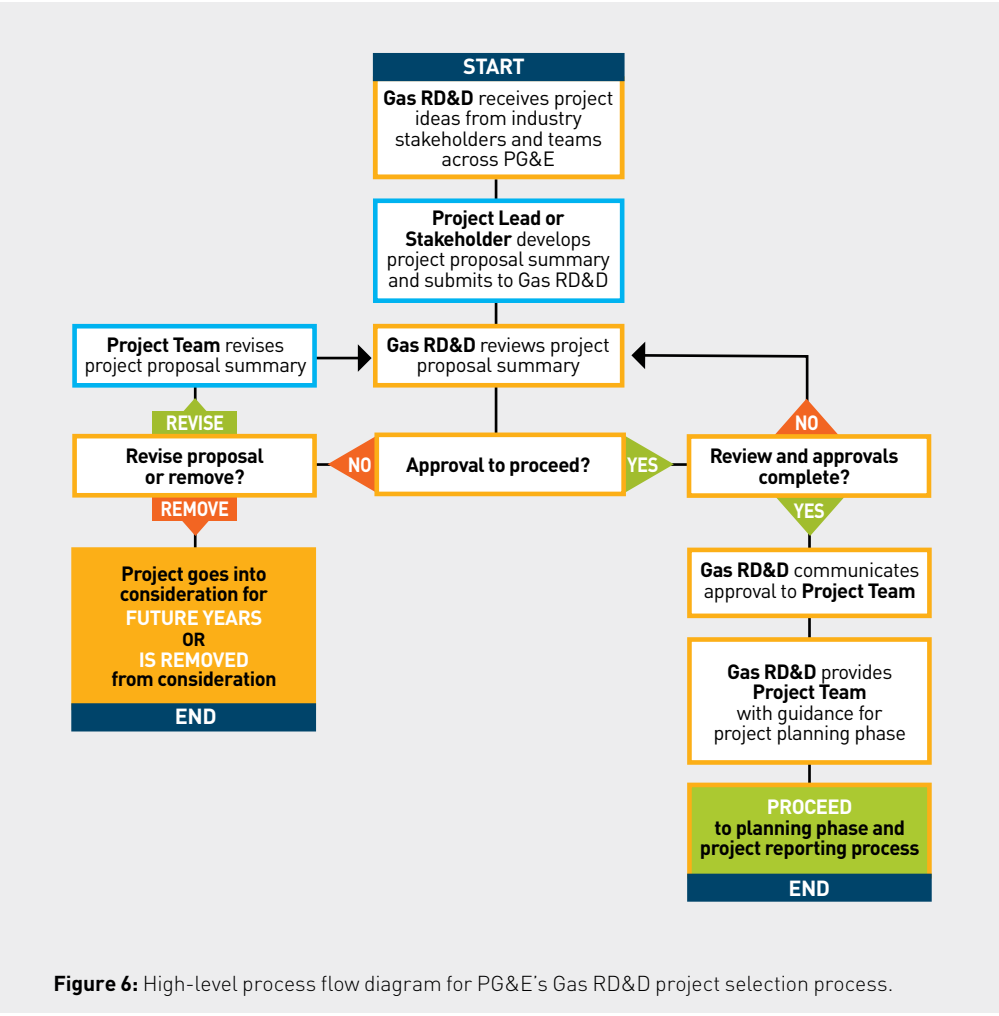


Figure 6: High-level process flow diagram for PG&E's Gas RD&D project selection process.

STRUCTURE OF PG&E'S GAS RD&D PORTFOLIO

PG&E's Gas RD&D team supports innovative projects and technologies across two main investment themes: Gas System Integrity and Decarbonization.

INVESTMENT THEME 1:
Gas System Integrity

INVESTMENT THEME 2:
Decarbonization

INVESTMENT THEME 1: Gas System Integrity

PG&E operates one of the nation's largest natural gas systems, comprising more than 50,000 miles of combined transmission and distribution pipeline serving approximately 4.5 million customer accounts. Operating and maintaining this system require substantial investments of time and resources every year.

These efforts take a variety of forms—from routine, periodic inspections and monitoring to emergency actions following natural disasters—and employ a wide array of technologies, ranging from aerial surveys to in-line and nondestructive inspection technologies. PG&E has also set ambitious goals for decreasing emissions over the next 15 years as part of our broader climate strategy.

While PG&E continually seeks and deploys state-of-the-art solutions to achieve these goals, the changing dynamics of its natural gas system in the face of accelerating electrification and decarbonization make innovation in these pursuits more imperative than ever.

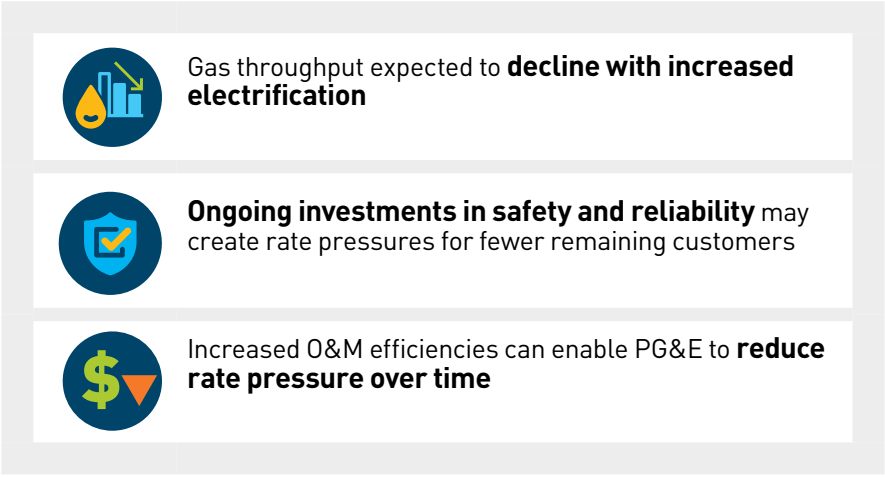


Figure 7: Expected declines in gas throughput may create rate pressures for fewer remaining customers.

Projects in the Gas System Integrity theme seek to develop or advance technologies that, if deployed widely, could improve gas system integrity and reduce methane emissions. Given the broad scope of PG&E's inspection, maintenance, repair, and emissions reduction efforts, there are numerous avenues through which novel technologies and solutions could make a meaningful impact on company operations.

Generally, projects in this investment theme seek solutions that could help automate, optimize, and improve existing processes based on a more comprehensive and real-time understanding of conditions across the system. If deployed widely, these technologies—including AI—could proactively address emerging challenges and efficiently direct resources based on risk level or other factors without the need for as frequent systemwide inspections to ensure safe and reliable delivery of energy across the system.

These projects will maintain and/or increase the safety and reliability of PG&E's existing gas system while reducing emissions and lowering unitized costs of work that will improve affordability for all customers—including those from ESJ communities.

Relevant problem statements

- Improving pipeline crack assessment technologies
- Verifying material properties for existing pipeline cost-effectively
- Reducing cost of well inspection and monitoring
- Enabling corrosion inspections for difficult to access spans
- Streamlining aboveground leak repairs
- Reducing the cost of T&D leak detection
- Reducing false positives on leak detection surveys
- Enabling remote meter set corrosion inspections
- Improving accuracy of well life estimations
- Increasing accuracy of geohazard risk assessment and monitoring
- Improving pipeline locating technologies
- Reducing cost of pipeline integrity inspection and monitoring
- Enhancing scalability of aboveground leak detection and monitoring
- Improving emissions calculation methodologies
- Eliminating methane emissions from transmission pipeline blowdowns

Gas RD&D's efforts in this theme are broadly focused on six initiatives:

- Geohazard risk management
- Compliance with new regulations
- Storage wells
- Advanced methane leak detection
- Revised emission calculation methodologies
- Efficient methane leak repair

GEOHAZARD RISK MANAGEMENT

THE CHALLENGE	THE SOLUTION
The industry's current ability to understand, predict, and model changing risk levels is insufficient for proactive identification of emerging geohazards. Assessments are conducted by costly inline inspection with limited capability or more costly digging to expose the pipe and conduct assessments.	• Provide better ongoing, non-intrusive or less-intrusive options, and/or less-frequent but more-capable inline inspection to increase visibility into the integrity of assets subject to increasing geohazard risks. • Enhance understanding of how developing geohazards may impact PG&E assets, including the ability to more accurately model these impacts. • Increase the ability to optimize the deployment of geohazard monitoring resources. • Reduce operation and maintenance costs.

COMPLIANCE WITH NEW REGULATIONS

THE CHALLENGE	THE SOLUTION
Per the Federal PHMSA New Mega Rule requirements, PG&E needs to expand the scope of many existing inspection and monitoring processes and deploy entirely new processes across many of our assets. This drives increasing O&M costs, resulting in significant impact on affordability.	• Develop more accurate, efficient, and cost-effective solutions for inspecting small-diameter pipes. • Verify the toughness of existing pipes via a non-destructive methods that are cost-effective, accurate, and repeatable. • Maintain or improve gas system safety and reliability to meet compliance requirements. • Proactively reduce costs and improve affordability, which is particularly important as gas throughput is expected to decline due to the transition toward non-fossil clean energy in the future.

STORAGE WELLS

THE CHALLENGE	THE SOLUTION
Per CalGEM and PHMSA Regulations on underground storage well integrity inspection and testing, current practices rely on periodic high-resolution, in-line technologies that are intrusive and may cause damage or introduce additional risk from frequent rig intervention activities. The current process requires that operations be shut down and tubing pulled out to complete the inspection. This can result in very costly inspections—up to $3 million per well for in-line methods.	• Develop more accurate, efficient, and cost-effective solutions for inspecting small-diameter pipes. • Verify the toughness of existing pipes via a non-destructive methods that are cost-effective, accurate, and repeatable. • Maintain or improve gas system safety and reliability to meet compliance requirements. • Proactively reduce costs and improve affordability, which is particularly important as gas throughput is expected to decline due to the transition toward non-fossil clean energy in the future. • Reduce the installation and real-time monitoring costs of continuous monitoring solutions, while ensuring high-quality, ongoing data transmission.

ADVANCED METHANE LEAK DETECTION

THE CHALLENGE	THE SOLUTION
The lack of cost-effective technologies to continuously monitor and quantify emissions from assets that intermittently bleed by design makes it difficult to estimate emissions.	• Drive down emissions through detecting methane leaks. • Quicken the survey process, assist in localization, and help quantify emissions. • Improve emissions reporting from stations and storage facilities. • Maximize emissions reduction efforts by prioritizing the highest emitters for replacement. • Reduce costs and improve affordability for all customers—including those from ESJ communities.

REVISED EMISSION CALCULATION METHODOLOGIES

THE CHALLENGE	THE SOLUTION
Although PG&E has made great progress in reducing emissions with respect to the Natural Gas Leak Abatement Program, there are still current limitations on reaching the emission reduction goal of 45 percent by 2030 (PG&E Climate Strategy goal). Figures for Transmission Metering and Regulating station emissions are not based on actual recorded emissions but instead on station level population-based emission factors. While efficient, this approach doesn't provide accurate emissions estimates and does not allow PG&E to demonstrate emissions reduction efforts.	• Collect necessary data to encourage an adjustment in emissions reporting framework. • Demonstrate emissions reductions through abatement efforts and programs. • Develop more granular emission calculation methods and the ability to continuously and cost-effectively detect and quantify on-site emissions levels at frequent intervals at the component level.

EFFICIENT METHANE LEAK REPAIR

THE CHALLENGE	THE SOLUTION
The current meter set leak repair process is time-consuming and increases ergonomic exposure for workers completing the repairs.	• Repair meter set leaks without breaking them down. • Develop novel technologies that minimize repair times, reduce the need for follow-up service visits, and maintain a high-quality seal that can handle pressure at 60 psi. • Develop technologies that support subsequent parts replacements and repairs. • Develop technologies that can remotely monitor meter sets for corrosion and successfully detect corrosion, alert repair crews, and/or shut off the meter set if failure is imminent. • Shorten meter set repair times and ensure a high-quality seal without breaking down the meter set. This could help reduce emissions and ensure worker safety while completing repairs.

PROJECT HIGHLIGHT

Current Magnetometry Inspection (CMI) Technology for Pipeline 3D Mapping

EMPIT's cutting-edge, non-intrusive, active CMI technology is capable of pipeline 3D mapping. In this process, it localizes and categorizes metal losses based on above-ground measurements of the magnetic field of the buried pipeline and the associated magnetic field changes associated with metal loss. This technology enhances the accuracy, efficiency, and reliability of pipeline geolocating under challenging scenarios and complements pipeline corrosion inspection and frequent monitoring at a fraction of the inline inspection cost, ensuring safer operations and minimizing environmental risks at a significant O&M cost reduction. The first field project will be focused on two concrete-coated, unpiggable backbone natural gas pipelines that are exposed on the bottom of the Sacramento River due to increasing erosion in recent years. In November 2024, the first field trial collected preliminary data from the main portion of the piggable pipeline. Preliminary analysis of the collected 3D mapping data shows promise; further analysis will be conducted in Q1 2025. The second field trial will be conducted in Q2–Q3 2025. The success of this work will provide PG&E with a techno-economically viable, low-cost solution for inspection, monitoring, and assessment of pipeline integrity under challenging water crossing conditions.

PROJECT HIGHLIGHT

Monitoring Emissions at Transmission M&R Stations using QLM Gas Sensing LiDAR

In 2024, PG&E completed an internal pilot project in conjunction with QLM Technology Ltd. The QLM LiDAR-based camera was used to continuously monitor emissions from 10 intermittent-bleed transmission M&R stations for 24-hour periods. Continuous monitoring data is necessary to accurately estimate emissions within station assets and in order to demonstrate abatement efforts.

INVESTMENT THEME 2: Decarbonization

In this research category, the Gas RD&D group funds projects that develop or advance technologies that, if deployed widely, would decarbonize the gas system.

Such projects include those that conduct foundational research that better informs the industry's understanding of the challenges and impacts of integrating cleaner fuels into existing pipelines and system assets, as well as into customer applications and end uses.

Decarbonizing the gas system is core to PG&E's True North Strategy, as well as supporting the achievement of broader decarbonization goals at state and federal levels; however, research continues about what this transition will look like at scale and how this transition will occur.

While it is widely accepted that hydrogen and other clean alternatives will likely be important fuel sources in the future, there is little certainty across the broader utility industry about exactly how these emerging fuels will be utilized in the future and how existing infrastructure and customer end uses will need to adapt to accommodate the switch from fossil-based natural gas. Foundational R&D and earlier stage research is needed. As a better understanding of cleaner alternative fuels emerges, their interaction with and impact on current system components and infrastructure and other operational considerations will help to inform the path towards greening the gas supply.

Relevant problem statements

- Understanding risks and impacts from trace RNG chemicals
- Increasing availability of operational data for hydrogen effects on gas system
- Mitigating hydrogen embrittlement at scale
- Understanding safety risks of hydrogen blend leaks
- Improving metering accuracy with hydrogen mixtures
- Ensuring compatibility of customer applications with mixed gas
- Reducing uncertainty of storage facility performance for hydrogen blends
- Eliminating gas appliance combustion emissions
- Facilitating cost-effective and safe deblending
- Enhancing gas quality analysis
- Reducing costs of interconnection skids
- Identifying cost-effective and scalable sources for RNG production
- Eliminating 100% of carbon emissions cost-effectively

To determine the optimal path to a net zero future, PG&E is seeking the help of the scientific community to deepen the industry's understanding of the economics, properties, and interaction effects of cleaner fuels.

Additionally, PG&E seeks avenues to extend this research beyond controlled laboratory settings to better inform the understanding of how hydrogen might affect existing gas infrastructure and operations under a wide range of real-world conditions.

Developing this base of knowledge is critical to the ability to smoothly transition the gas system to clean alternatives. Beyond foundational research, the Gas RD&D team is also pursuing novel approaches and technologies that will help address known barriers to the introduction of cleaner fuels to the gas system. As the path forward becomes clearer over the coming years, PG&E anticipates that its RD&D needs related to decarbonizing the gas system will shift away from foundational research and towards deployable technology necessary to effect the transition.

Gas RD&D's efforts in this area are broadly focused on two initiatives:

- Impact of hydrogen
- Integrating cleaner fuels

IMPACT OF HYDROGEN

THE CHALLENGE	THE SOLUTION
As hydrogen and other green alternatives become more widely accepted, the importance of studying how this emerging fuel will be utilized and how existing infrastructure and customer end uses must adapt becomes critical.	• Study hydrogen utilization to understand its impact on the gas system, customer end uses, and appliances, and adapt existing infrastructure accordingly. • Support the interaction between traditional energy resources and emerging fuels. • Achieve affordability by repurposing natural gas pipelines and avoiding additional electrical infrastructure costs. • Reduce GHG emissions, benefiting ESJ communities. • Provide training and education opportunities in hydrogen blending pipeline operations. • Offer municipalities cost-effective community-based energy options, encouraging exploration of hydrogen and renewable energy.

Effects on existing system components and operations

1. Pipeline integrity
2. Storage well integrity
3. Safety characteristics
4. Metering accuracy

Effects on existing customer end uses and appliances

1. Compatibility with various customer end uses and appliances
2. Deblending at customer sites

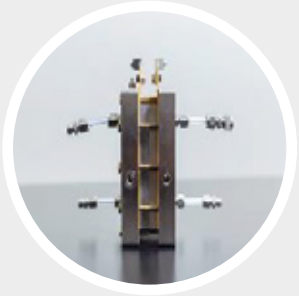
INTEGRATING CLEANER FUELS	
THE CHALLENGE	**THE SOLUTION**
In the transition to a net zero energy system by 2040, PG&E seeks to integrate clean fuels such as traditional RNG, non-traditional RNG, renewable hydrogen, and synthetic methane.	• Integrate clean fuels such as traditional RNG, non-traditional RNG, renewable hydrogen, and synthetic methane. • Support R&D and pilot projects exploring cost-effective interconnection. • Address feedstock limitations. • Ensure compatibility with existing infrastructure and processes. • Develop novel fuel production processes.

Traditional RNG

RNG created from **traditional organic sources:** livestock, landfills and wastewater treatment

Non-Traditional RNG

RNG created from **non-traditional organic sources:** woody biomass, food waste, etc.



Synthetic Methane

RNG created from **other sources:** power-to-methane, etc.

PROJECT HIGHLIGHT

UTD Project 1.22.P "Emerging Distributed Methane Pyrolysis Technologies"

This project aims to classify emerging distributed methane pyrolysis solutions as good, better, or best fit for gas ratepayers and consumers to decarbonize their operations. By combining application/process modeling with end-user demand modeling and technology assessments, the research team conducted primary research through direct outreach to leading technology developers. They created a landscape survey of distributed methane pyrolysis technologies, including a techno-economic assessment (TEA) over various applications. The survey addressed conversion processes, hydrogen end uses, and carbon outputs. Current efforts are expanding this analysis with additional outreach and refinement of the TEA. The primary target markets are large commercial and industrial sectors, with initial applications in processes or boilers where solid carbon can be collected. The project addresses UTD goals to reduce GHG emissions and accelerate the transition to hydrogen as a low-carbon fuel. It explores turquoise hydrogen, produced via methane pyrolysis, which offers advantages over green and blue hydrogen pathways. The project includes a thorough modeling assessment, analytical feedback, R&D gap summary, and pre-feasibility analysis for prospective demonstrations. Phase 1 results will refine the TEA and update assumptions based on new information and industry scale-up efforts.

APPENDICES

2024 Policy drivers

CATEGORY	REGULATIONS AND POLICY DRIVERS
CPUC Proceedings	**CPUC Order Institute Rulemaking (OIR) 24-09-012:** This OIR to Establish Policies, Processes, and Rules to Ensure Safe and Reliable Gas Systems in California and Long-Term Gas System Planning. **CPUC OIR R.13-02-008, Phase 4:** Establishes biomethane procurement targets for investor-owned utilities in California. **CPUC ESJ Action Plan:** Mandates the integration of equity considerations into all CPUC decisions and policies to address ESJ issues, prioritizing benefits for disadvantaged communities and ensuring fair access to clean energy and utility services.
GHG Emissions	**Assembly Bill (AB) 32:** Reduce CO_2 emissions 40% below 1990 levels by 2030 **Senate Bill (SB) 100:** Zero-carbon electricity by 2045 **AB 1279:** By 2045, achieve a carbon-neutral California economy and reduce statewide anthropogenic GHG emissions to at least 85% below 1990 levels **AB 3232:** Building decarbonization **SB 1101:** Carbon Sequestration: Pore Space Ownership and Carbon Capture, Utilization, and Storage Program
Pipeline Safety	**CPUC General Order 112F:** Rules governing design, testing, operation, and maintenance of gas transmission and distribution systems **U.S. Department of Transportation (DOT) 49 Code of Federal Regulations Part 192:** Federal pipeline safety regulations **AB 1900:** Biomethane quality standards **OIR R.13-02-008, Phase 4:** Addresses injection of renewable hydrogen into gas pipelines
Local Air Quality	**Clean Air Act:** Air quality standards for NOx and PM **AB 617:** Pilot communities for air quality improvements

CATEGORY	REGULATIONS AND POLICY DRIVERS
Methane Emissions	**SB 1383:** Reduce methane emissions from decomposition of organic wastes **California Air Resources Board Oil and Gas Rules:** Requires new monitoring and repairs to reduce methane emissions **Natural Gas STAR Program:** Encourages adoption of methane-reducing technologies and practices **EPA Methane Challenge Program:** Recognizes oil and gas companies that take comprehensive action to reduce methane emissions **SB 1440:** Authorizes a state procurement program for RNG
Clean Transportation	**ARB Implementation Plan:** Low-NOx standard for trucks **AB 8:** Development of 100 hydrogen fueling stations in California **EO-B32-15:** Sustainable freight action plan **EO-B48-18:** 200 hydrogen refueling stations by 2025 **EO N-79-20:** 100% of medium- and heavy-duty vehicles be zero emission by 2045 for all operations where feasible **Low Carbon Fuel Standard:** Reduce carbon intensity of fuels by 10% by 2020 **SB 1275:** One million zero-emission and near-zero-emission vehicles by 2023
Equity	**CPUC General Order 156:** Encourages IOUs to procure or contract goods and services from women, minority, disabled veteran and/or LGBT owned business enterprises **CPUC ESJ Action Plan:** Increases investment in clean energy resources to benefit environmental and social justice communities, especially to improve local air quality and public health

2024 Alignment with CPUC policies and proceedings

INITIATIVE	ALIGNMENT
Geohazard Risk	Research on geohazards, including seismic risks, landslides, and erosion, aligns with multiple CPUC policies and proceedings to enhance the safety and reliability of gas infrastructure. CPUC Proceeding R.13-11-006's Risk-Based Decision-Making Framework prioritizes safety by identifying and mitigating geohazard risks. General Order No. 112-F's design and maintenance standards are informed by geohazards research, preventing damage from seismic events, landslides, and erosion. Long-term gas planning and reliability standards in Proceeding R.20-01-007 benefit from robust geohazard mitigation strategies. Policies established in Proceeding R.24-09-012 ensure safe and reliable gas systems by addressing seismic, landslide, and erosion risks. Finally, Decision D.20-01-0022 integrates geohazard research into utility rate cases, promoting comprehensive safety and reliability improvements. Together, these alignments fill identified research gaps and support the development of resilient gas infrastructure.
Compliance with New Regulations	Research related to compliance with new regulations under the PHMSA natural gas transmission regulations aligns with multiple CPUC policies and proceedings to enhance pipeline integrity management and safety. CPUC Proceeding R.13-11-006's Risk-Based Decision-Making Framework prioritizes safety by identifying and mitigating pipeline risks. General Order No. 112-F's design and maintenance standards are informed by compliance research, preventing pipeline failures and enhancing safety. Long-term gas planning and reliability standards in Proceeding R.20-01-007 benefit from robust compliance strategies. Policies established in Proceeding R.24-09-012 ensure safe and reliable gas systems by addressing pipeline safety and integrity. Finally, Decision D.20-01-0022 integrates compliance research into utility rate cases, promoting comprehensive safety and reliability improvements. Together, these alignments fill identified research gaps and support the development of resilient pipeline infrastructure.

INITIATIVE	ALIGNMENT
Storage Wells	Research related to storage wells aligns with multiple CPUC policies and proceedings to enhance the safety and reliability of underground natural gas storage facilities. CPUC Proceeding R.13-11-006's Risk-Based Decision-Making Framework prioritizes safety by identifying and mitigating risks to storage wells, with CalGEM's collaboration ensuring comprehensive risk management. General Order No. 167's maintenance and operation standards are informed by storage wells research and CalGEM's expertise, preventing failures and enhancing safety. Long-term gas planning and reliability standards in Proceeding R.20-01-007 benefit from robust storage wells strategies and CalGEM's collaboration. Policies established in Proceeding R.24-09-012 ensure safe and reliable gas systems by addressing the safety and integrity of storage wells, with CalGEM's input. Finally, Decision D.20-01-0022 integrates storage wells research into utility rate cases, promoting comprehensive safety and reliability improvements with CalGEM's insights. Together, these alignments fill identified research gaps and support the development of resilient underground storage infrastructure.
Advanced Methane Leak Detection	Advanced Methane Leak Detection technologies align with CPUC policies and proceedings by enhancing the accuracy and efficiency of leak detection, thereby supporting the mandatory best practices outlined in Decision D.17-06-0151. These technologies contribute to Rulemaking R.24-09-012 by providing innovative solutions for monitoring and managing gas infrastructure, enhancing system reliability and safety. Additionally, research in Advanced Methane Leak Detection directly addresses the objectives of Rulemaking R.15-01-008 by developing technologies that can detect and quantify methane leaks more effectively, supporting the reduction of greenhouse gas emissions and compliance with established rules and procedures.
Revised Emission Calculation Methodologies	The "Revised Emission Calculation Methodologies" research aligns with CPUC policies and proceedings by enhancing the accuracy of methane emission quantification, which is critical for effective implementation of best practices established in D.17-06-015. It supports R.24-09-012 by providing precise emission data necessary for safe and reliable gas system planning. Additionally, it addresses gaps in emission reporting under R.15-01-008, thereby advancing the goals of minimizing natural gas leaks and improving greenhouse gas reduction efforts. This comprehensive approach ensures that the methodologies contribute significantly to the CPUC's regulatory framework and environmental objectives.

INITIATIVE	ALIGNMENT
Efficient Methane Leak Repair	The "Efficient Methane Leak Repair" research aligns with CPUC policies and proceedings by enhancing the effectiveness and timeliness of methane leak repairs, which is critical for implementing best practices established in D.17-06-015. It supports R.24-09-012 by providing rapid leak detection and repair methodologies necessary for safe and reliable gas system planning. Additionally, it addresses gaps in leak repair efficiency under R.15-01-008, thereby advancing the goals of minimizing natural gas leaks and improving greenhouse gas reduction efforts. The research also contributes to R.13-11-006 by offering data-driven solutions for leak repair prioritization, enhancing safety outcomes. Furthermore, it supports General Order 112-F by providing advanced techniques for leak detection and repair, ensuring compliance with operational and maintenance standards. This comprehensive approach ensures that the methodologies contribute significantly to the CPUC's regulatory framework and environmental objectives.
Impact of Hydrogen	PG&E's research is providing innovative solutions to support the CPUC proceedings, particularly in the context of D.22-12-057. This decision mandates California's large gas investor-owned utilities to file annual reports related to biomethane projects and procurement, starting May 1, 2024. It also directs the development of pilot projects to evaluate standards for the safe injection of clean renewable hydrogen into California's common carrier pipeline system. PG&E's research focuses on specifying permissible injection thresholds, locations, testing requirements, and conducting independent analysis to ensure the safe integration of hydrogen into the existing gas infrastructure. Additionally, the SB 1075 bill complements this decision by requiring the California Air Resources Board (CARB), in collaboration with the California Energy Commission and CPUC, to produce a comprehensive report on hydrogen, covering its development, deployment, and use across all sectors. These efforts collectively support California's climate, air quality, and energy goals, paving the way for a cleaner, more sustainable energy future.
Integrating Cleaner Fuels	PG&E's research is providing innovative solutions to support the CPUC proceedings, particularly in the context of D.22-12-057 and D.22-02-025. In D.22-12-057, PG&E's research focuses on developing pilot projects to evaluate and establish pipeline injection standards for clean renewable hydrogen, ensuring safe integration into California's gas infrastructure. This includes specifying permissible injection thresholds, locations, testing requirements, and conducting independent analysis. In D.22-02-025, PG&E's efforts align with setting biomethane procurement targets and establishing procurement methods for investor-owned utilities, promoting the integration of cleaner fuels like biomethane into the gas supply. These initiatives collectively support the state's goals of reducing greenhouse gas emissions and advancing renewable energy sources, thereby contributing to a cleaner, more sustainable energy future.

CPUC best practices (BP): D.17-06-015 Natural Gas Leak Abatement Program

CATEGORY	BP	TITLE	MAIN POINTS
Company Policy	**BP 2**	Methane Potent GHG Policy	Company policy stating methane is GHG with reference to SB 1371 and SB 1383
	BP 3	Pressure Reduction Policy or Procedure	Company policy stating pressure reduction of transmission lines to lowest possible pressure before blowdown
	BP 5	Methane Evacuation Implementation Procedures	Company procedures for drafting, cross-compression, flaring
	BP 6	Methane Evacuation Work Orders Policy	Company policy that requires Work planners to include emission reduction steps in work plan
Leak Detection	**BP 15**	Gas Distribution Leak Surveys	Move from 4-year to 3-year leak survey. Company can propose new technology.
	BP 16	Special Leak Surveys	Predictive leak analytics for supplemental special leak survey programs
	BP 17	Enhanced Methane Detection	Use of enhanced methane detection practices mobile methane detection, aerial leak detection
	BP 18	Stationary Methane Detectors	Use of stationary methane detectors at compressor stations, storage facilities, M&R stations
	BP 19	Above Ground Leak Surveys	To include in Compliance plan, frequent leak detection and data collection and above ground stations and facilities including use of optical gas imaging and other methods.
	BP 20	Leak Quantification and Geographic Evaluation/ Tracking	Improved quantification and geographic tracking of leaks.
Leak Repairs	**BP 21**	"Find It Fix It Policy": Leak Repair Timeline and Backlogs	To specify leak repair times that exceed the minimum regulatory requirement and to eliminate backlogs. To require TLA leaks to be fixed immediately. Also suggests that leaks have to be repaired within 3 years of discovery.
Leak Prevention	**BP 23**	Prevent/Minimize/Stop Fugitive and Vented Methane Emissions	Replacement of high-bleed pneumatic devices to low-bleed. Reduction of emissions from blowdowns.

Acronyms, initialisms, and definitions

ACRONYM	DEFINITION
AB	Assembly Bill
AI	Artificial Intelligence
ASME	American Society of Mechanical Engineers
Belonging	One of PG&E's core values. Belonging means coworkers feel seen for their unique contributions, connected to coworkers and leaders, supported in their daily work and professional growth, and proud of our purpose, virtues, and stands.
BP	Best Practice
CEC	California Energy Commission
CER	Consensus Engineering Requirement
CH_4	Methane
CMI	Current Magnetometry Inspection
CP	Cathodic Protection
CPUC	California Public Utilities Commission
DEIB	Diversity, Equity, Inclusion, and Belonging
DOE	US Department of Energy
EFI	Emerging Fuels Institute
ENG	Engineering Network Group
EO	Executive Order
ERG	Engineering Resource Group
ESJ	Environmental and Social Justice

ACRONYM	DEFINITION
LiDAR	Light Detection and Ranging
M&R	Measurement and Regulation
MMT	Million Metric Tons
NGA	Northeast Gas Association
NSF	National Science Foundation
NYSEARCH	A voluntary sub-organization within the Northeast Gas Association
O&M	Operations and Maintenance
OIR	Order Instituting Rulemaking
OTD	Operations Technology Development
PG&E	Pacific Gas and Electric Company
PHMSA	Pipeline and Hazardous Materials Safety Administration
PRCI	Pipeline Research Council International
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RNG	Renewable Natural Gas
RY	Reporting Year
SAR	Safety, Affordability, and Reliability
SB	Senate Bill
T&D	Transmission and Distribution
TNS	True North Strategy
UTD	Utilization Technology Development

Project summaries:
Gas System Integrity

1.14.g.6: RMD Phase 6: Support for NFPA Standard Development

The project aims to create a comprehensive program for achieving full customer adoption of cost-effective, reliable, accurate, and readily available residential remote methane detectors (RMD). The program will include technology development and evaluation, codes and standards development, stakeholder engagement, and economic and market analysis. The project kicked off in 2014 and has had six subsequent phases completed in 2024. Post-project steps include performing ventilation tests to verify proper exhaust of gases, testing devices at 10% and 25% lower explosive limits to ensure they are in correct working order, and initiating exposure lab tests. Odorant alone may not be enough for customers to report leaks. An in-home alert system would provide a proactive approach to gas leak detection and improve safety.

Co-Funders: ConEd/O&R, Dominion, National Grid, GRDF, ATMOS, Avista, DTE, Duke Energy/Piedmont, Intermountain, LA RDC, National Fuel, Nicor Gas, NiSource/Columbia, NW Natural, NYSEG/RGE, ONE Gas, Peoples Gas, PG&E, PSNC Energy, SoCal, Southwest Gas, TECO, Washington Gas, APGARF

Start Date: 7/1/2021
End Date: 8/1/2024
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$48,000**
Total PG&E Cost:	**$4,000**
Total Co-Funding:	**$44,000**

Benefits

1.18.F Ph 2 Mitigate Methane Emissions ResCom End Use

This project will quantify methane emissions from at least six key residential appliances that have yet to be tested in past phases of the project. The goal is to 1) develop and publish representative methane emission factors, 2) determine the conditions under which these appliances release unburned methane, and 3) identify potential mitigation options. At least six residential appliances, including cooking ranges and tank water heaters, will be tested under specific operating conditions and representative use patterns, including steady-state, standby, and cyclic operation. In 2021 under Phase 2, researchers prepared the testing area and instrumentation for testing furnaces. The team conducted several shakedown tests to address issues with the methane analyzers, instrumentation, control programs, and data acquisition. The team completed testing of the first furnace (two-stage 80% AFUE), and they tested the remaining furnaces in early 2022 under Phase 3. The other furnaces included a single stage and two modulating condensing units. The team collected total hydrocarbon emissions data for both steady-state and part-load tests to generate a full picture of the emission profile for typical furnace operation. The team has started data analysis for the Final Report since the experimental phase is completed for Phase 2. The team will quantify the methane emissions profiles for the four furnaces at various part-load conditions to generate emission factors. Differences in emissions will be correlated to operational differences to understand how the team can mitigate emissions in equipment design and operation. In 2024, the project team completed the experimental phase. Final data analysis and reporting is underway.

Co-Funders: UTD members

Start Date: 8/1/2020
End Date: 5/29/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$145,000**
Total PG&E Cost:	**$25,000**
Total Co-Funding:	**$120,000**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.18.F Ph3 Mitigating Methane Emissions from ResCom End Use Equipment

The objective of this project is to quantify methane emissions from at least six key residential appliances that have not been quantified in past phases of the project, in order to develop and publish representative methane emission factors and to determine the conditions under which these appliances release unburned methane and identify potential mitigation options. At least six residential appliances, including cooking ranges and tank water heaters, will be tested under specific operating conditions and representative use patterns, including both steady-state, standby and cyclic operation. Emission factor results from this phase and past phases of the project will be combined in a spreadsheet tool for estimating residential methane emissions based on appliance type and operating pattern.

Co-Funders: UTD members

Start Date: 8/1/2021
End Date: 5/22/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$10,000
Total Co-Funding:	$140,000

Benefits

5.16.k.2 Ph2 ORFEUS Obstacle Detection Technology for HDD

The project aimed to produce a field-proven, market-ready obstacle location technology for horizontal directional drilling (HDD) applications. Optimized Radar to Find Every Utility in the Street (ORFEUS) is an effort to develop a safe, cost-effective, "look-ahead" obstacle detection system for HDD equipment. This project seeks to develop further the technology to bring forward a commercially viable product for identifying obstacles in and around the path of an HDD drill rig, thus reducing third-party damage to underground utilities. The ORFEUS technology incorporates a forward- and side-looking ground-penetrating radar within the HDD. This process will detect obstacles within the HDD path during the installation of new underground infrastructure. This technology could lower the risk of damaging substructures during the boring process. In 2023, the project team completed developing and debugging the data acquisition module and finalized the modifications of the ORFEUS detection algorithm and the angular sensor board. Calculating pitch and angular speed in real time is now possible. Additional validation tests took place in Europe to confirm the performance of the recent upgrades. Field demonstrations in Europe took place during May and June 2024. Future technology enhancements incorporating the lessons learned from the field demonstrations are scheduled for a future project phase. PHMSA hosted the final project presentation on September 13, 2024. PG&E is developing a plan for field demonstrations starting in 2025. The benefits of successful technology would provide an opportunity to reduce HDD damage that could affect the integrity of PG&E's pipelines, reduce safety concerns, and reduce the release of emissions into the atmosphere.

Co-Funders: OTD members, PHMSA, Southern California Gas

Start Date: 1/14/2021
End Date: 9/13/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$3,500,000
Total PG&E Cost:	$350,000
Total Co-Funding:	$3150,000

Benefits

5.17.m.2 Modify Pipeline Purging Program for Calculations of Methane Emissions Savings, Including H_2

The objective of this project is to update the pipeline purging software program to allow users to more easily calculate methane emissions savings from using various types of purging alternative processes and equipment (i.e., cross compression) and hydrogen blending operations). The project team will create new calculation algorithms, user interface, and software installation and set-up and provide beta and production versions of the software with a user manual as a final deliverable. If successful, accurately capturing savings in the volume of gas loss can assist PG&E make better financial decisions about which emission reduction work to fund.

Co-Funders: SoCalGas, OTD members

Start Date: 8/30/2023
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$174,000
Total PG&E Cost:	$1,000
Total Co-Funding:	$173,000

Benefits

5.19.f.2 Ph2 Purging Gas Pipes into Service w/o Venting Gas

The project aims to develop an alternative method to purge gas pipes into service with minimal to no gas released into the atmosphere. There is an industry need to commercialize a cost-effective vacuum purging system to mitigate methane emissions from traditional purging practices. A vacuum purging system could enhance public safety and reduce unaccounted gas losses. Phase 1 of the project was completed in Fall 2020. The vacuum purging method was validated through a market needs assessment, and a commercial partner was identified for production. Phase 2 began in 2021 when GTI Energy developed an enhanced vacuum system and validated it on main and service pipelines. The vacuum system can be used to commission new or repaired pipes without venting natural gas into the atmosphere as the vacuum compressor removes the remaining air or inert gas from within the pipeline. Once the proper vacuum level is reached, natural gas can be introduced into the pipe without venting or mixing air and natural gas. The next steps will include field trial demonstrations and beginning commercial production of the technical solution. Upon completion of the project, GTI Energy plans to conduct field trial demonstrations and begin commercial production of the technical solution.

Co-Funders: Ameren, ATMOS, ConEd/O&R, Dominion, Duke Energy/Piedmont, LA RDC, National Fuel, National Grid, Nicor Gas, PG&E, PSNC Energy, Southwest Gas, Washington Gas, APGARF, Black Hills Energy, NiSource/Columbia, NW Natural, NYSEG/RGE, ONE Gas, SoCal, TECO

Start Date: 11/20/2020
End Date: 7/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$175,000
Total PG&E Cost:	$17,500
Total Co-Funding:	$157,500

Benefits

5.20.k Smart Shut-off Tech for Residential and Commercial Buildings

The project aimed to provide the natural gas industry with the necessary hardware and software components to create a complete smart shutoff system solution. This integrated approach consists of remote monitoring and control, capable of detecting and terminating gas flow in response to a hazardous incident such as a fire, flood, or gas leak inside a residential or commercial structure. This project was co-funded by the California Energy Commission (CEC) to improve the safety and integrity of natural gas infrastructure. The final report was published on September 4, 2024. The project team completed simulated demonstrations of the comprehensive gas smart shutoff safety system (CGSSSS) technology for subject matter experts at SoCal Gas, PG&E, and TECO at their corporate training centers. Following the initial demonstrations, two CGSSSSs using a wireless communication network were assembled, demonstrated, deployed, and observed at a residential building and a commercial building. The demonstrations successfully illustrated that a gas leak or fire in a building can be detected by smart sensors, alerts can wirelessly be communicated to utility first responders to improve safety, and the gas can be shut off to the building either by a programmed alert setting or remotely by the gas utility. However, wider deployment of a CGSS will depend on the existence of a LoRaWAN Class B network, which is not widely available within PG&E's service territory. Any future development of an integrated system will most likely be based on a cellular communications system.

Co-Funders: OTD members, CEC, Southern California Gas

Start Date: 8/4/2020
End Date: 9/4/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$1,230,000
Total PG&E Cost:	$7,000
Total Co-Funding:	$1,223,000

Benefits

5.20.k.2 Addition of Low Power WAN (LPWAN) Communication Network

This project is being managed under parent project 5.20.k. The project aimed to provide the natural gas industry with the necessary hardware and software components to create a complete smart shutoff system solution. This integrated approach consists of remote monitoring and control, capable of detecting and terminating gas flow in response to a hazardous incident such as a fire, flood, or gas leak inside a residential or commercial structure. This project was co-funded by the California Energy Commission (CEC) to improve the safety and integrity of natural gas infrastructure. The final report was published on September 4, 2024. The project team completed simulated demonstrations of the comprehensive gas smart shutoff safety system (CGSSSS) technology for subject matter experts at SoCal Gas, PG&E, and TECO at their corporate training centers. Following the initial demonstrations, two CGSSSSs using a wireless communication network were assembled, demonstrated, deployed, and observed at a residential building and a commercial building. The demonstrations successfully illustrated that a gas leak or fire in a building can be detected by smart sensors, alerts can wirelessly be communicated to utility first responders to improve safety, and the gas can be shut off to the building either by a programmed alert setting or remotely by the gas utility. However, wider deployment of a CGSS will depend on the existence of a LoRaWAN Class B network, which is not widely available within PG&E's service territory. Any future development of an integrated system will most likely be based on a cellular communications system.

Co-Funders: OTD members, CEC, Southern California Gas

Start Date: 11/1/2021
End Date: 9/4/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$82,000
Total PG&E Cost:	$7,500
Total Co-Funding:	$74,500

Benefits

5.22.j Ph1 Design and Placement of Compact Service Regulators

This project aimed to review existing practices and perform comparative testing on vent-limiting service regulators to determine installation requirements. The final report was published on December 26, 2024. Many utilities use the "minimum distance to a source of ignition" requirement for indoor and outdoor regulators listed in the National Fuel Gas Code, which is based on the venting characteristics of standard internal relief valve regulators and not on vent-limiting regulators. The results determined if vent-limiting service regulators offer more options for outdoor installation by having a smaller footprint of ventilated gas that could justify reduced clearances. The project included additional testing on two of the non-relieving gas service regulators to determine their sensitivity to trips due to temperature increases. The draft final report was provided to PHMSA in Q4 2023 and finalized in Q4 2024. The project provided scientific data demonstrating that newer vent limiting gas service regulators with an over pressure shut off (OPSO) vent less gas emissions as compared to traditional IRV during abnormal conditions. The test plan provides a list of gas service regulators that were tested as part of this project, however the manufacturer and model for each of the regulators is not listed in the results section of the public report. PG&E is using data to support use of vent-limiting service regulators from this research to improve safety, reduce cost, reduce emissions, and benefit ratepayers. The results would be used to develop a more detailed policy and criteria regarding the appropriate sites and usage of the non-relieving service regulators.

Co-Funders: OTD members, PHMSA

Start Date: 11/19/2021
End Date: 12/26/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$489,629
Total PG&E Cost:	$1
Total Co-Funding:	$489,628

Benefits

5.24.c Alternative Purging Closed Combustion Development

The purpose of this project is to develop an alternative purging technology by designing and testing an enclosed combustion control device that can safely and effectively evacuate natural gas from a pipeline with reductions in methane emissions and customer impact as compared to traditional purging practices. This project has the ability to increase safety by reducing the need for traditional purging methods and simultaneously reduce emissions.

Co-Funders: OTD members

Start Date: 3/1/2024
End Date: 6/15/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$267,000
Total PG&E Cost:	$10,200
Total Co-Funding:	$256,800

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

5.24.m Field Pilot of Real-Time Pipeline Threat Detection System (SPADE System)

This Operation Technology Development (OTD) project aims to assess and validate the SPADE technology for detecting and locating mechanical impacts through pilot run at 3 field sites in PG&E service territory. This is a pre-commercialization effort following the successful completion of 2023 Pipeline Research Council Internal (PRCI) ROW-1-01 technology feasibility study. In addition, this work will increase the precision of locating mechanical defects from the distance between rectifiers to the distance between engineering test stations. The project kicked off in Q1 2024, completed field site survey in Q2 2024 and shortly afterwards added the extra requirement on UL Safety Certification from PG&E Corrosion Engineering/ Field Operation. By Q4 2024, UL Safety Testing was successfully passed, the field installation was completion and the monitoring devices have started the initial remote real-time continuous monitoring configuration testing. The project was delayed for about 6 months due to the addition of UL Safety Certification beyond the original project scopes. Now it is targeted for completion in Q4 2025 and possibly will be extended for one more year to better assessment this pilot trial. Upon successful completion of this project, PG&E and other operators will be able to use, maintain, and manage the SPADE systems as state-of-the-art technology for enhancing pipeline reliability, energy deliverability, public safety, and environmental protection—and do it all cost-effectively.

Co-Funders: OTD members

Start Date: 3/14/2024
End Date: 12/31/2026
Status: Active

2024 Funds Expended:	**$4,8624**
Total Project Cost:	**$477,497**
Total PG&E Cost:	**$324,827**
Total Co-Funding:	**$152,670**

Benefits

5.24.p Ph1 Addition of Landis Gyr G480 Meter to the Ultrasonic

This project will evaluate the accuracy of the meter metrology, long-term performance, compliance with meter standards, and smart shut-off capabilities of the Landis+Gyr G480 and Honeywell AC NXU 250 ultrasonic residential gas meters. The project builds upon projects 5.19.h Single-Path Ultrasonic Meter Performance Testing (Short-Term) and 5.20.e Single-Path Ultrasonic Meter Long-Term Performance Testing and Monitoring. Testing will include compliance with ANSI B109.6—Single Path Ultrasonic Meters and DIN EN 14236—Ultrasonic Domestic Gas Meters, OIML R137—Gas Meters, and GTI Energy developed tests. Currently, the industry does not have independent short-term or long-term performance and accuracy data for the Landis+Gyr G480 Ultrasonic residential gas meter nor the Honeywell AC NXU 250 Ultrasonic residential gas meter. This data is required for LDCs to make an informed decision on how and if to implement this new meter technology within their gas distribution systems. In addition, some public utility commissions require independent third-party performance testing before allowing LDC's to install these types of meters under their jurisdiction. Evaluating the effectiveness and performance of these meters will increase market adoption of ultrasonic meter technology. Testing began in Q3 2024 and will continue into 2025.

Co-Funders: OTD members

Start Date: 8/29/2024
End Date: 1/1/2026
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$230,000**
Total PG&E Cost:	**$23,742**
Total Co-Funding:	**$206,258**

Benefits

5.24.v Development of a Low-Cost Hydrogen Sensor for in-Pipeline Application

GTI Energy will develop a high-accuracy (<0.5%), low-cost hydrogen sensor to detect 0% to 100% hydrogen concentrations. Fuel mixture properties (heating value, Wobbe Index, etc.) will be configured using existing data from GTI Energy and demonstrate the sensor in at least two OTD member field sites. This project will also summarize existing commercially available hydrogen sensors. The project was kicked off in October 2024. The project team is coordinating field sites for sensor prototype testing.

Start Date: 10/1/2024
End Date: 10/1/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$200,000
Total PG&E Cost:	$10,000
Total Co-Funding:	$190,000

Benefits

Co-Funders: OTD members, University of Wisconsin, Madison

5.24.y Ph2 LLFA Tape

The purpose of this project is to pilot the LLFA tape solution for repairing non-hazardous meter set leaks. If successful, PG&E field services will have another tool in the toolbox to perform non-hazardous meter set leak repairs which can improve safety by reducing repetitive motion injuries, reduce methane emissions from meter set assembly leaks, and reduce operating and maintenance costs by streamlining and quickening leak repairs. The LLFA tape product will be used to repair 100 MSA leaks in PG&E territory. Following the repairs, monthly rechecks will be done for at least 6 months, to ensure all weather conditions are taken into consideration.

Start Date: 4/25/2024
End Date: 11/30/2025
Status: Active

2024 Funds Expended:	$7783
Total Project Cost:	$188,738
Total PG&E Cost:	$88,738
Total Co-Funding:	$100,000

Benefits

Co-Funders: N/A

7.16.a.3 Leak Repair Prioritization Ph3

The project team is further exploring the development of leak rate estimation algorithms developed in Phases 1 and 2, which began in 2016 and were initially focused solely on prioritization of leak repair. Phase 3 advances these estimation algorithms by combining the collected data with advanced modeling and a detailed estimation equation developed by the University of Texas-Arlington (UT-Arlington). This phase of work focuses on non-hazardous leaks (e.g., Grade 2 or 3) that pose minimal safety hazards. The project results are valuable to the industry as survey crews need an easily deployable method or instrument to quantify leak rates. If leak rates could be quantified, more significant leaks could be prioritized for repair to maximize methane leak mitigation. The deliverable includes a final report combining existing methods with new insights from UT-Arlington's estimation equations and advanced modeling techniques. The report will include revised emission rate conversion charts based on soil type and borehole/pavement testing findings. Unfortunately, during the project update in Q4 2023, GTI Energy determined that developing the model as a practical tool for leak rate estimation is not attainable. Rather than proceed with the fieldwork, GTI Energy recommends concluding this project. A final report was issued in Q2 2024, and a simplified model that could estimate the leak emission rate was developed to estimate physical parameters that are not directly measurable in real-time by a leak survey technician. Unfortunately, this is not deployable as the model training was deemed insufficient due to a small sample of leaks that all were skewed to very low emission flow rates. A larger leak data set that includes a range of higher flow rates is required to establish proper training of the model and can be looked at in the future.

Co-Funders: Ameren, APGARF, ATMOS, Avista, ConEd/O&R, Intermountain, LA RDC, National Fuel, National Grid, NW Natural, NYSEG/RGE, Peoples Gas, PG&E, Duke Energy/Piedmont, Enbridge, PSNC Energy, SoCal, Southwest Gas, Spire, TECO, Washington Gas

Start Date: 2/28/2022
End Date: 12/31/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$1,000
Total Co-Funding:	$149,000

Benefits

7.17.d.3 Soap Solution Comparison Study for Rate Estimation/Hazard Assessment

The objective of this project was to perform a comparison study between soapy solutions to understand if solution additives lead to variations in bubble sizes and formation rate. The project team completed testing on several soap solutions varying the pressure, flow rate, and temperature. The final report was published in Q3 2024 with the results showing an insignificant change in the resulting appearance of foam or bubbles due to the additives in four separate solutions. This method has been successfully deployed into operations for estimating MSA leaks.

Co-Funders: OTD members

Start Date: 8/18/2023
End Date: 8/1/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$125,000
Total PG&E Cost:	$1,000
Total Co-Funding:	$124,000

Benefits

7.20.f Ph1 Characterizing Methane from Purging

The objective of the project was to develop a method to quantify the volume of natural gas emitted during the commissioning of a pipeline. With increasing pressure on operators to measure, report, and reduce methane emissions, developing a method to quantify emissions released during purging is crucial. GTI Energy validated this method in preparation for field studies. It is envisioned that the knowledge gained from this project could be applied to emergency blowdowns later. The project began in 2020 and was completed in Q3 2024. Unfortunately, further tests are needed to validate the results of this project, but a few main takeaways from the study were purging procedures that require 95%–100% methane concentration from CGIs may lead to excess emissions during the procedure, a static mixer upstream of a purge vent may offer efficiency gains like reduced time in purging procedures and measuring oxygen may better indicate when a purge has been completed. CGIs are often calibrated for methane. Hence, natural gas quality and methane concentration can vary based on origin, meaning CGI readings may also vary, whereas air will have a more consistent composition.

Co-Funders: ATMOS, ConEd/O&R, Dominion, Enbridge, National Grid, Nicor Gas, PG&E, Southwest Gas, Duke Energy/Piedmont

Start Date: 4/1/2020
End Date: 9/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$100,000
Total PG&E Cost:	$20,000
Total Co-Funding:	$80,000

Benefits

7.20.g Gas Mapping LiDAR for Distribution Leak Detection

Aerial based leak detection technologies offer the potential for surveying larger areas for leaks which can in turn allow for rapid of large emitters and leader to a greater emissions reduction. Bridger Photonics developed the Gas Mapping LiDAR (GML) system, a commercially available air-based platform for survey and leak detection that can be mounted to a fixed-wing or rotary aircraft platform. It uses laser based optical gas imaging, geospatial information systems (GIS), and Light Detection and Ranging (LiDAR) detect and quantify methane emissions. The system sensitivity under normal conditions is 0.5 kg/hr (26.8 scfh) for a greater than 90% probability of detection (PoD.) The objective of this project was to evaluate the ability of the Bridger Photonics Gas Mapping LiDAR (GML) system to detect distribution leaks using this air-based platform. GTI Energy performed field demonstrations of the Bridger GML's performance in detecting distribution leaks as well as quantifying emission rates with controlled releases. The project was completed in 2024 with the deliverable being a final report listing the following main takeaways. The GML attached to a rotary wing aircraft detected all controlled releases as well as a "blank," or no-gas controlled release. Controlled releases below the high confidence PoD level and as low as 5 scfh were also performed with the GML making repeated detections of the gas releases. The quantification error however, ranged from 4%–720%. This included testing the system at emission rates below 26.8 scfh and down to 5 scfh so large quantification errors were expected. This technology has the potential to detect larger natural gas leaks more efficiently within the distribution segment, compared to solely using walking survey or vehicle-based methods.

Co-Funders: ATMOS, Avista, LA RDC, National Grid, Nicor Gas, NYSEG/RGE, PG&E, Southwest Gas, Spire, TECO, APGARF, Duke Energy/Piedmont

Start Date: 1/14/2021
End Date: 1/1/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$180,000
Total PG&E Cost:	$10,000
Total Co-Funding:	$170,000

Benefits

7.20.l Methane Mitigation Using Linear Recovery Motor Comp

The project seeks to design, build, and test a high-pressure linear motor leak recovery compressor for cost-effective recovery of methane leaks within the natural gas value chain's transmission, storage, gathering, and processing sectors. Such a tool would reduce methane emissions from PG&E compressor stations. The project team designed and built the compressor using a proven linear motor architecture. The linear motor compressor enables multiple compression stages to be integrated into a single moving part, allowing the compressor to function under a broad range of operating conditions and reach the high discharge pressures required for gas recovery without the cost and complexity of traditional multi-stage compressors. The project will validate the technology's effectiveness in various relevant environments to identify the wide-ranging applications for its use. The project began in 2020 and, due to delays, is now expected to be completed in 2025. In Q4 2023, the GTI Energy team continued to finalize outstanding design items that are holding up the final fabrication and assembly of the leak recovery compressor. The unit is currently being fabricated to prepare for lab testing in 2025.

Co-Funders: OTD members, DOE, SoCal

Start Date: 11/4/2020
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,917,000
Total PG&E Cost:	$129,060
Total Co-Funding:	$1,787,940

Benefits

7.21.b Advanced Tools for Methane Emissions Estimation

This project sought to develop an advanced tool to estimate emission rates by incorporating spatial methane concentration measurements. This tool is crucial to reducing methane emissions because leak grading relies only on concentration measurements rather than leak rate quantification. The proposed approach intended to use air dispersion physics models and deep learning algorithms to enhance estimation and prediction accuracy. This project kicked off in 2021 and was intended to be completed in 2023. Unfortunately, the GTI Energy team encountered multiple challenges, including blockers in the implementation related to the applicability of small leaks and a sparse number of sensors, a limited understanding of the roles and significance of some parameters, and a limited knowledge of the strategy for using mobile data versus static measurement. This project demonstrated a proof of concept for an advanced methodology to locate and quantify above-ground methane leaks. The approach involved optimizing model parameters to maximize the likelihood of observed field measurements, providing histograms for each parameter to assess confidence and suggest improvements. The project was closed out in 2024.

Co-Funders: ATMOS, ConEd/O&R, Dominion, National Grid, ONE Gas, PG&E, Southwest Gas, TECO, Washington Gas, APGARF, Duke Energy/Piedmont

Start Date: 1/1/2021
End Date: 8/31/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$140,000
Total PG&E Cost:	$14,000
Total Co-Funding:	$126,000

Benefits

7.21.f. Establishing an Auditor Training Program for Differentiated Gas

The objective of this project was to publish a white paper outlining a technical framework to certify Responsible Natural Gas with guidelines on how to report environmental attributes of a gas product important to utilities. Currently, gas suppliers and certifying organizations lack a standardized method for reporting and quantifying GHGs, including methane emissions, natural resources, and other Environmental Social Governance factors. CARB has started estimating the out-of-state methane emissions for the California natural gas supply. AGA and EEI are promoting a system of reporting estimates of upstream methane emissions based on the protocol developed by M.J. Bradley and Associates. PG&E and other OTD Members were interested in incorporating Certified Gas into their business plans, and utilities have the unique need to integrate methane emissions along with upstream gas suppliers and reconcile the various methods to assess emissions. During the state-of-the-art assessment, the project was rescoped in response to white papers published by Highwood Emissions Management, Rocky Mountain Institute, and Resources for the Future which achieved most of the deliverables originally planned for this project. The new deliverable was to require the project team to create training materials and establish an auditor training program to assess methane emissions for all segments of the gas value chain based on the protocols developed under GTI's Differentiated Gas Initiative. This was successfully done by GTI energy. Benefits include the improved emissions quantification along the value chain, resulting in enhanced identification of sources and corresponding mitigation measures.

Co-Funders: OTD members

Start Date: 1/1/2021
End Date: 9/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$207,000
Total PG&E Cost:	$16,000
Total Co-Funding:	$191,000

Benefits

7.23.o Methane Detection Technology—Regulation Equivalence Testing

The objective of this project was to develop a protocol to evaluate leak detection technologies on a common benchmark, highlighting functional differences and comparing effectiveness. Equivalence testing of various technologies provided an understanding of detection effectiveness and of performance comparisons, despite equipment variations. The protocol aimed to be agnostic across various detection technologies. The results from this project may assist PG&E in streamlining evaluation and acceptance processes and reducing the number of tools needed for regulated surveys in the future.

Co-Funders: OTD members

Start Date: 8/18/2023
End Date: 12/31/2025
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$200,000
Total PG&E Cost:	$1,000
Total Co-Funding:	$199,000

Benefits

7.24.b NPRM ALDP Performance Rule 5ppm at 5 ft Evaluation

This project aims to evaluate the new proposal rulemaking (NPRM) Advance Leak Detection Program (ALDP) by PHMSA 5ppm at 5 feet. PHMSA has proposed establishing a leak detection performance criterion to ensure that the utility industry performs leak surveys to a standard. However, the suggested performance criteria are not within the ability of commercially available leak survey instruments. Further, these performance criteria will also be used to audit surveys and evaluate how utilities continue to improve their leak survey program. Having a performance criterion that is clear, definable, and measurable is critical to its successful implementation.

Co-Funders: OTD members

Start Date: 1/1/2024
End Date: 3/31/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$602,300
Total PG&E Cost:	$70,683
Total Co-Funding:	$531,617

Benefits

7.24.c Ph 1 Near Field Fixed Monitoring

The objective of this project was to evaluate the use of fixed methane monitors for leak detection at underground storage. Due to various factors, the probability of detection was lower than expected. To enhance the probability of detection, lessons learned in Phase 1, such as proper sensor placement and controlled gas release technique, will be incorporated into Phase 1B. Phase 1B is planned to start in Q1 2025 and will test the best-performing sensors while incorporating the lessons learned in Phase 1.

Co-Funders: OTD members

Start Date: 11/20/2023
End Date: 6/30/2024
Status: Completed

2024 Funds Expended:	$43,166
Total Project Cost:	$73,000
Total PG&E Cost:	$40,874
Total Co-Funding:	$32,126

Benefits

8.20.L Enhanced Locating Technologies for Underground Pipelines with Better Accuracy

The final report was published on March 30, 2024. The objective of the project, co-funded by the California Energy Commission (CEC), was to improve the safety and integrity of underground natural gas pipelines by increasing the accuracy of horizontal and vertical pipeline location data. The approach was based on enhancing and adapting existing 3D electromagnetic detection technology to locate buried metal pipelines. The project supplemented existing technology with Reduct's in-pipe mechanism to focus on congested areas and plastic materials. Pilot demonstrations were conducted on transmission lines with White River Technologies APEX technology at Situation City in Pico Rivera and at SoCalGas's Wheeler Ridge Compressor Station. The Reduct In-pipe Mapping and Locating Technology was demonstrated on distribution line test sites in Winters and Elk Grove with PG&E and Charge EPC, respectively. Based on the survey results at two pilot demonstration sites, compared to the commercial EM tool, the APEX system showed 30–73% reduction in horizontal errors and 80–97% reduction in vertical errors. PG&E can use this research to add to the list of tools that identify steel assets without excavation, an approach that will improve affordability, reliability, and safety. Additionally, the Reduct in-pipe mapping system showed promise at the demonstration at PG&E's Winters training facility on July 18, 2022. Learnings included the form factor will require additional work to be compatible with the rugged conditions of being on a job site and the stuffing box would need to be reassessed from a safety perspective to ensure safe operations and SOPs developed. Reduct will continue its work on improving its in-pipe mapping system. Additional testing at PG&E may occur in the future.

Co-Funders: OTD members, CEC, White River Technologies

Start Date: 11/4/2020
End Date: 4/1/2024
Status: Completed

2024 Funds Expended:	**$0**
Total Project Cost:	**$2,021,631**
Total PG&E Cost:	**$12,554**
Total Co-Funding:	**$2,009,077**

Benefits

8.20.m 3D Visualization Software for Mapping Underground

The project was completed on March 31, 2024. The objective of the project, co-funded with the California Energy Commission (CEC), was to develop 3D visualization software for mapping underground pipelines and improving asset management. A significant amount of third-party damage to buried infrastructure is associated with inaccurate or insufficient locating practices. Knowing the location of buried infrastructure can significantly aid in mitigating risks and preventing damage. GTI Energy developed 3D visualization software. First, GTI Energy analyzed several existing and proven technologies and field-tested them to create the Locate Technology Platform (LTP). This platform is intended to assist field users in visualizing infrastructure location data from various viewpoints. In 2022, data collection and field demonstrations of the LTP utilizing several locating devices were performed by two sponsors, including PG&E. In 2023, the CEC updated and approved the Pilot Demonstration and Analysis document that included the demonstration results. The project team also worked on technical knowledge transfer activities. A beta version of the software was developed. Additional development will be required to be field-ready. This technology could save field time, lowering the data collection cost. PG&E may utilize the software to improve the three-dimensional geospatial accuracy of existing Geographic Information Systems data.

Co-Funders: CEC, SoCalGas, OTD members

Start Date: 12/2/2020
End Date: 3/31/2024
Status: Completed

2024 Funds Expended:	**$3,320**
Total Project Cost:	**$2,090,436**
Total PG&E Cost:	**$45,000**
Total Co-Funding:	**$2,045,436**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

8.24.L Commercialization of GSA Smart Pole

The objective of this project is to evaluate the integration of the GNSS Smart Automation (GSA) technology developed by GTI Energy into a working GPS prototype to assess the effectiveness and viability of this product. This work will occur with Bed Elf, which has a pole-mounted GNSS system. The project entails producing five prototype GPS devices for testing at select sponsor locations, including one for testing at GTI Energy in Des Plaines. GTI and Bad Elf will coordinate requirements-gathering sessions with all sponsors in order to understand the expectations of the equipment and current needs. From there, 1–2 sponsors will be chosen to conduct pilot demonstrations to test deployment and usability in the field. The results will inform the commercialization phase. Pilots assume that 1–5 devices will be deployed in the field for short-duration pilots (2 weeks to 2 months). This technology would improve the collection of high-accuracy GNSS data by field crews through automation of capturing a location data point, which will improve the quality and consistency of the data collected. This can also reduce the time and personnel needed to collect data, further reducing costs and improving efficiency. Pilots will occur during 2025.

Co-Funders: OTD members

Start Date: 10/1/2024
End Date: 12/31/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$170,000
Total PG&E Cost:	$119,000
Total Co-Funding:	$51,000

Benefits

8.24.m Steel Material Traceability Unique ID and Smart Tags

The objective of this project is to convert the specification for steel material traceability Unique IDs and Smart Tags into an API Recommended Practice. Previous work funded by OTD and PRCI developed a specification for Unique IDs, Smart Tags, and Digital MTRs. Previous deliverables include: 1) API Recommended Practice for Digital MTRs (API RP 5MT); 2) Digital MTR template based on API RP 5MT; 3) Portal for Digital MTR exchange; 4) Specification for Unique IDs and Smart Tags for Steel Pipe; 5) Tool for generating Unique IDs; and, 6) SCATE Resource Center. The work in this project will add Unique IDs and Smart Tags to provide a complete RP for steel pipe traceability. The API work group began work in 2024 and will take approximately 18 months to complete.

Co-Funders: OTD members, PRCI members

Start Date: 10/1/2024
End Date: 10/1/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$3,194
Total Co-Funding:	$146,806

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

ADV JIP Integrity Management of Hard Spots in Transmission Pipelines

This Joint Industry Project (JIP), being sponsored by ADV Integrity (An Acuren Company), is to establish a framework for the integrity management of high hardness areas in pipelines, including manufactured hard spots. The framework will incorporate a review of historical data, detection and quantification methods, and performance assessment through sub-scale and full-scale testing. A key outcome will be guidance on the response criteria for in-line inspection results. Also included in this study will be an assessment on the impact that the transport of hydrogen could have on the integrity of natural gas pipelines. This JIP kicked off in Q1 2023 and is on track to completion in Q4 2024. The outcome of this JIP will provide PG&E and other operators with an improved capability to manage the threat level that a particular hard spot poses to the integrity of the pipeline. A pragmatic approach, rather than a theoretical one, will be produced to assist operators in identifying and addressing factors that contribute to hard spot failure. This JIP will improves PG&E's integrity management of pipelines with possible Hard Spots, and will accelerate PGE development of internal standards and processes to locate and mitigate hard spots.

Co-Funders: JIP operator members and material manufacturing members

Start Date: 1/31/2023
End Date: 5/12/2025
Status: Active

2024 Funds Expended:	**$100,000**
Total Project Cost:	**$900,000**
Total PG&E Cost:	**$100,000**
Total Co-Funding:	**$800,000**

Benefits

ADV JIP Narrow Groove Corrosion Composite Reinforcement

On average, PG&E's gas transmission system is over 50 years old and continues to age and the industry is seeing fatigue cracking become more of an issue. To repair sharp, narrow, or crack-like defects in gas transmission pipelines, PG&E has very limited options: a welded steel sleeve, or cutting out the pipe as a cylinder. Composite wrap reinforcements have proven to be effective at repairing general corrosion and other blunt wall defects, but studies need to prove their effectiveness for reinforcing sharper grooving and crack-like defects as well as retarding fatigue crack growth. This JIP is to evaluate the performance of composite repair systems for the reinforcement of groove corrosion features using full-scale testing, focusing on three specific objectives: 1) Composite repair optimization in terms of optimized thickness; 2) Reinforcement of groove corrosion/metal loss features; and, 3) Evaluating the effects of internal pressure during installation. This is to expand the cost-effective composite reinforcement application to selected seam weld corrosion (SSWC) and also optimize composite repair designs beyond the inherent conservatism in ASME PCC-2 pipeline operating conditions. The work started in July 2024 and expected to be completed by March 2025. Upon field deployment after successful completion of this work, PG&E expects to save $50k to $2M per unit cost than the existing sleeve weld or pipe replacement.

Co-Funders: Project members: 7 pipeline operators and 7 manufacturers

Start Date: 7/25/2024
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	**$50,289**
Total Project Cost:	**$650,000**
Total PG&E Cost:	**$50,000**
Total Co-Funding:	**$600,000**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

ADV/Acuren Lab Verification Study on Non-Destructive Residual Stress Measurement

This work is to review of the State-of-the-Art in-ditch residual stress technologies and conduct lab study to verify an indentation based non-destructive stress measurement technology that can be easily used in the ditch. Korea based Frontics and UK based technology Plastometrex are the two technology providers with the related tools that will be tested in this work by ADV Integrity (an Acuren company with strong knowledge/experience in stress engineering). Currently both vendors have supplied the similar type of tools for in-ditch steel pipe yield strength measurement. Indention tips with the associated data analytics are the major difference between the stress measurement and the material yield strength measurement. The work kicked off in December 2024 and is expected to complete by December 2025. The success of this work will immediately benefit the active TIMP Hard Spot Inspection and Management program by providing another important NDE tool for in-ditch validation of ILI detected hard spots, which can eliminate unnecessary ILI digs for huge cost saving. As a foundation technology, it can also save millions of dollars for other types of anomaly detection, assessment and mitigation programs. In addition, this initiative will likely lead to a more comprehensive deep dive in various potential in-ditch and inline stress measurement technologies at industrial consortia.

Co-Funders: N/A

Start Date: 12/2/2024
End Date: 12/2/2025
Status: Active

2024 Funds Expended:	$50,938
Total Project Cost:	$50,000
Total PG&E Cost:	$50,000
Total Co-Funding:	$0

Benefits

BLV CH4 Drone Mounted Sensor for Leak Survey

The purpose of this project was to evaluate the BLV-CH4 drone mounted sensor for leak survey to potentially provide PG&E leak survey team with another tool in the toolbox for performing leak survey specifically during emergency response, and for areas with large vegetation overgrowth. Because this sensor utilizes TDLAS technology, the sensor itself does not have to travel through the plume and can be used at a distance away enhancing safety for personnel. The project was completed following 2 field trails in the Hercules area and at the Winters gas safety academy with promising results.

Co-Funders: N/A

Start Date: 8/1/2024
End Date: 12/1/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$1
Total PG&E Cost:	$1
Total Co-Funding:	$0

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

CPS-17-04A Improved GHG Fugitives Leak Detection

The project seeks to identify isolation valves in the PG&E system that exhibit large leaks. Since multiple valves are typically manifolded to a single vent, it can be challenging for operators to determine which valves require replacement or repair. Through-valve gas leakage from natural gas compressor unit suction and discharge isolation valves is a significant source of methane emissions in natural gas transmission and storage. Addressing this critical source of methane leaks will substantially 1) improve the ability to contain greenhouse gas emissions, 2) demonstrate a proactive response, and 3) contribute to PG&E's reduction target commitments. At the test facility (owned by SoCalGas), the project team tested multiple technologies that signal through-valve leakage when pressurized, including three thermal imaging infrared cameras and three acoustic measurement devices. Field tests delivered promising results at pressures up to 400 pounds per square inch for two forward-looking infrared cameras and three acoustic measurement devices. The contractor finalized a report summarizing the results, and a no-cost time extension was issued through 3/8/2024.

Co-Funders: SoCalGas, PRCI members, OTD members

Start Date: 11/8/2021
End Date: 3/31/2024
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$120,000
Total PG&E Cost:	$10,000
Total Co-Funding:	$110,000

Benefits

Dev and Eval of a Hi-Res Historical Climate Dataset over CA

The objective of the project is to assemble historical California climate data to improve two models for forecasting weather conditions. The improved models will enable utilities to assess infrastructure risks associated with exposures to short- and long-term extreme weather events. Weather forecasting models are used to find utility infrastructure vulnerabilities in extreme weather events. Such events include extreme dry conditions posing wildfire threats and extreme wet conditions causing floods and mudslides. The two climate models currently used for forecasting are 1) West Weather Research and Forecasting Model for California "dry" simulations and 2) Desert Research Institute's Weather Research and Forecasting Model for California "wet" simulations. The University of California San Diego and the Scripps Institution of Oceanography were awarded this California Energy Commission project. They will assemble climate data from California between 1980 and 2019 to improve both models for forecasting weather conditions. The datasets and model results will be available online to utilities, climate researchers, and the public. PG&E is participating in the Technical Advisory Panel for the project. In 2024, the project has run simulations over 5 selected case study areas to consider cloudiness, Santa Ana winds, heat wave(s), and atmospheric rivers. Currently, the dynamical model simulations are producing 6km and 2km downscaling results covering October 2012–2023. Additional years will be downscaled once the first 11 years are completed. PG&E will use the results of this project as part of its geohazard risk management plan that protects infrastructure from future extreme weather events and energy supply disruptions to ratepayers.

Co-Funders: UC San Diego-Scripps Institute, Southern California Gas

Start Date: 1/19/2021
End Date: 6/30/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,363,550
Total PG&E Cost:	$1
Total Co-Funding:	$1,363,549

Benefits

EC-01-13 ILI-Based Generic External Corrosion Growth Rate Distributions for Buried Pipelines

The objective of the project was to provide the industry with generalized In-Line Inspection-based (ILI) corrosion growth rate distributions and associated causal factors. The growth rate distributions were based on actual data from successive ILI runs provided by Pipeline Research Council International members. The project team developed a probabilistic model for estimating external corrosion growth (ECG) rates via subsequent ILI runs. The team identified four key parameters and associated elements that could be used to establish generic Corrosion Growth Rates (CGRs): 1) pipeline service time, 2) corrosion control system effectiveness, 3) environmental aggressiveness (i.e., the impact of environment on corrosion), and 4) ILI results, if available. The report identified these parameters, with classifications assigned to each parameter. The project team delivered a supplemental document, "PR-186-213600-E01 Generic External Corrosion Growth Rate Distributions Parameter Guidelines," as a sample matrix that provides different combinations of results for each parameter's elements that can be classified. The report emphasized that these combinations are just guidelines; users can develop their own metrics. Pipeline operators could utilize project results to establish data-driven and justifiable ECG rates on pipelines, which cannot be calculated from historical and ILI run-to-run comparisons. PG&E can utilize this research study to increase the accuracy of ECG rate calculations used to determine the remaining life of pipelines and apply them to pipelines that are either new to the Transmission Integrity Management Program, only have only one ILI run, or that are difficult to inspect and currently assessed by External Corrosion Direct Assessment programs. Unfortunately the project and project team had difficulty/challenges with data availability/quantity and quality that limits the usability as well as the ability to validate the results.

Co-Funders: PRCI members

Start Date: 5/15/2021
End Date: 3/27/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$193,662
Total PG&E Cost:	$19,308
Total Co-Funding:	$174,354

Benefits

EC-02-12 SRP CM Evaluation of Selective Seam Weld Corrosion

This PRCI Crack Management Strategic Research Priority project is to advance the methodologies, tools, and techniques used by pipeline operators to determine the susceptibility of line pipe to the threat of selective seam weld corrosion (SSWC) through execution of the following tasks: Task 1—Define selective seam weld corrosion vs. corrosion incidental to the LSW; Task 2—Develop a summary of the current state of the art for SSWC; Task 3—Analyze seam weld microstructure and chemistry; Task 4—Explore the evaluation and validation of field deployable techniques for determining susceptibility to SSWC; Task 5—Develop guidelines for implementation of SSWC susceptibility models to identify and prioritize pipeline segments for seam integrity assessment. This work started in July 2022 and completed all the remaining works except the final report in 2023. It generated a summary of the evaluation performed of the threat of selective seam weld corrosion (SSWC) to line pipe that contain autogenous welds, the threat's susceptibility parameters, and methodologies that could be used to better determine susceptibility. As a result of the project, a literature review was performed for the purpose of understanding the threat as well as its susceptibility parameters. A benchmarking effort was also conducted to determine which of the susceptibility parameters could be collected, or are already readily available, and were indicative of susceptibility based upon industry data (both in-kind support and publicly available data). The project also included an investigation into field deployable techniques. The project included testing to validate, and possibly to refine, the linear polarization resistance (LPR) approach of the Barnacle probe. Using the results of the literature, a high-level process to discriminate between SSWC and other corrosion morphologies coincident to the longitudinal seam weld was also developed. By Q3 2024, the final project report was successfully completed. Based on the successful completion of this work, PG&E and other operators expect to see a reduction in threat profile over time in an efficient and effective manner by performing assessments where the SSWC threat is most likely to occur and not where it isn't, leading to much improved safety, reliability, efficiency and cost-effectiveness.

Co-Funders: PRCI members

Start Date: 7/26/2022
End Date: 7/2/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$200,000
Total PG&E Cost:	$20,000
Total Co-Funding:	$180,000

Benefits

EC-2-10 2019 Development of a Comprehensive Metal-loss Assessment Criteria

This project aims to develop Level 1 and Level 2 metal-loss assessment criteria that are easy to use and cover all pipe grades and construction eras. The metal-loss assessment criterion will indicate the risk of leak and rupture, reduce inspection data scatter, and eliminate maintenance that does not affect risk reduction. The project integrates and builds on work completed in prior research, which developed a criterion for metal-loss assessment demonstrated in an independent evaluation to significantly reduce data spread and address bias in contrast to the American Society of Mechanical Engineers B31G and Modified B31G models. This criterion will allow for less scatter, conservatism, and other assessment models without compromising pipeline operational safety. In 2023, the project team completed the verification of coalescence criteria for adjacent and nested metal loss features. By the end of the year, the project team had finished developing the three key technology factors that will determine the success of the remaining work on the project, including 1) more accurate burst pressure prediction of multiple complex features than existing models; 2) coalescence criteria that can be used for the prediction of leaks versus ruptures; and 3) leak versus rupture prediction using the coalescence criteria. By end of 2024, all the project tasks such as FEA modeling and validation testing have been completed or nearly completed. The next step is to complete the remaining tasks (Feature decomposition; Assessment workflow; Leak vs, rupture testing) and deliver the draft project final report by March 2025. Upon successful completion, this work will provide PG&E and other gas operators with a comprehensive and representative assessment of failure pressure in areas of corrosion damage, which will avoid being too conservative in the current practices. This, in turn, will result in effectiveness, efficiency, and cost reduction at no sacrifice of safety.

Co-Funders: PRCI members

Start Date: 2/28/2019
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,493,000
Total PG&E Cost:	$201,800
Total Co-Funding:	$1,291,200

Benefits

Electromagnetic and Optical Sensor Technologies for Natural Gas Storage Safety Monitoring

The project will support CEC PIR-19-1, developing and demonstrating an integrated suite of novel, autonomous, and real-time natural gas wellbore integrity monitoring technologies based on distributed electromagnetic (EM) and fiber optic reflectometry methods. The approach combines novel guided-wave EM Time Domain Reflectometry (EM-TDR) with state-of-the-art Brillouin scattering-based Optical Time Domain Reflectometry (BO-TDR) methods for distributed monitoring of underground gas storage well borehole conditions over its entire length. The combination of EM-TDR and BO-TDR provides a multi-modal, multi-physics diagnosis of borehole health conditions by providing 1) EM signals from corrosion or stress-related borehole damages and 2) fiber optic strain and temperature signals from borehole operation, deformation, or leakage events. The project kicked off in July 2020, with field installation at PG&E's McDonald Island Underground Storage Facility completed in July 2021. In 2023, the project team successfully monitored several operation events, interpreting data via the installed fiber optic sensor systems. The team has completed the remaining on-demand monitoring via the fiber optic sensor system by Q2 2024 and submitted 3 papers to peer-review technical journals by Q4 2024. Due to its low technology readiness level, the EM-TDR portion mainly focused on lab study and model development. Significant further development is needed after project completion. Upon completing this work by Q4 2024, PG&E can continue the non-invasive, minimally invasive, on-demand monitoring of wellbore health using the installed fiber optic sensor system and conduct improvement of data analytics as well as technoeconomic assessment for large-scale deployment in the future , which will ultimately enhance the reliability and resiliency of underground gas storage, allow the proactive identification of potential leakage or integrity risks especially with emerging fuels, and support informed decision-making in a very cost-effective way.

Co-Funders: CEC, Lawrence Berkeley National Lab

Start Date: 7/16/2020
End Date: 12/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$2,280,000
Total PG&E Cost:	$440,000
Total Co-Funding:	$1,840,000

Benefits

Evaluating Emissions from Transmission M&R stations

The project collected emissions data from transmission Metering and Regulating (M&R) stations using Sensit Fix Point Laser methane detectors. Transmission M&R stations represent the top three emitters in PG&E's territory. The California Public Utilities Commission and the California Air Resources Board have mandated that California utilities reduce emissions by 20% by 2025 and 30% by 2040. The current method and structure for reporting and calculating emissions uses a population-based emission factor. This approach is problematic because it fails to show the impact of the methane reduction strategies implemented by PG&E to lower emissions in the reported data. To accurately show emissions reductions in the data, it's necessary to develop measurement-based emission factors instead of population-based ones. The main source of station emissions are pneumatic devices which can be categorized into low, intermittent, and high bleed. Open path sensors were installed at stations from each category to continuously monitor emissions and collect data for several months. Measurements with other devices were also taken in tandem. The results have been presented to the CPUC to help us encourage updating transmission station emission factors.

Co-Funders: N/A

Start Date: 8/21/2017
End Date: 12/1/2024
Status: Completed

2024 Funds Expended:	$3,970
Total Project Cost:	$117,100
Total PG&E Cost:	$117,100
Total Co-Funding:	$0

Benefits

Fiber Optic Sensor Monitoring of Pipeline Strain Under Geohazards (R-1143)

The project supports Pipeline and Hazardous Materials Safety Administration (PHMSA) projects #6913G620P8000102 and #693JK32050007CAAP by using state-of-the-art distributed fiber optic sensing technologies to examine the feasibility of long-term monitoring of buried gas pipelines that are potentially vulnerable to ground deformation across faults and landslides related to PG&E's fault crossing mitigation project (R-1143) in Gilroy, California. The project will develop and test materials and techniques for cost-effective, secure, and permanent attachment of sensors to pipelines. The researcher will work with domestic fiber-optic cable companies to manufacture a tightly coupled fiber-optic cable with a predicted lifetime of over 30 years that accurately measures strain, temperature, and acoustics on pipelines for long-term monitoring of pipeline structural performance when subjected to ground movements at fault crossing and landslide sites. In addition, the newly developed reliable, accurate, and economically viable direct strain monitoring tool for pipelines under geohazard conditions will provide full-scale field data to help calibrate the existing finite element analysis models for the first time in the industry. This will significantly improve the effectiveness and efficiency of geohazard assessment and mitigation. In 2023, the project team successfully tested and installed the systems at a PG&E field site. On-demand monitoring started in September 2023. The next step is to continue on-demand tracking and the development of related data analytics.

Co-Funders: UC Berkeley, Paulsson Inc.

Start Date: 8/11/2021
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,241,000
Total PG&E Cost:	$1
Total Co-Funding:	$1,240,999

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

Field Trial of EMPIT's Technology for Inspecting Pipeline Exposed at Sacramento River Bottom

This project is to address a recent field request for the safety concerns from the California Land Commission on 2 concrete coated unpiggable pipelines (L-400-2 MP142) exposed at the Sacramento River bottom in Red Bluff, CA, due to increasing erosion in recent years. Re-routing via HDD is not feasible geologically. Live pipe inline inspection using tetherless robotic tool (~$2.5–3M) and/or out-of-service tethered line tool full inspection ($5M) are very costly and cannot be executed in the near term. Divers tried twice in the past and could not even perform the coating inspection due to strong water stream. There is a lack of techno-economically viable commercial sour monitoring solutions that can be implemented now in this river crossing case, especially as even the advanced offshore inspection solutions for subsea cannot be implemented due to insufficient water depth in the river. Before the costly high-resolution inline inspection can be conducted, if possible a few years later, a non-intrusive, low-cost screening/monitoring solution that can be implemented quickly is really needed to address the safety concerns. After a comprehensive brainstorming and search for creative solutions, the non-intrusive, low-cost active magnetometry technology (EMPIT's Current Magnetometry Inspection Technology) on a boat platform has been identified as the only available techno-economically viable solution that may likely be able to address this challenging case. This field trial is to conduct: 1) non-intrusive inspection and assessment of the pipeline coating and corrosion; 2) 3D mapping of the pipelines with the depth of cover measurement; 3) bending strain assessment. The close-by piggable L-401 line with available ILI data is used as a reference to help evaluate the EMPIT's performance. In Q4 2024, the 1st field trial collected some preliminary data on the main portions of the pipelines and was paused due to harsh weather conditions. The preliminary analysis of the collected 3D mapping data of L-401 presented a few weeks after shows quite promising, and further analysis will be conducted in Q1 2025. The stopped fieldwork will be resumed in the June-July 2025 timeframe when there are no weather concerns, plus higher water levels to avoid possible hit by rocks close to the northeast bank. The delivery of the final project report is expected by Q4 2025. The success of this work will provide PG&E with a techno-economically viable low-cost solution for inspection/monitoring and assessment of pipeline integrity under challenging water crossing conditions.

Co-Funders: N/A

Start Date: 11/18/2024
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$142,049
Total Project Cost:	$200,000
Total PG&E Cost:	$200,000
Total Co-Funding:	$0

Benefits

IM-1-08 Pragmatic Application of MegaRule RIN 1—192.712 Toughness Values

The Pipeline and Hazardous Materials Safety Administration introduced the MegaRule RIN 1—192.712, which offers simplified guidelines for assessing the need for repairs on axial flaws detected by in-line inspections (ILI) based on Charpy energy values at 50°F. However, these guidelines do not adequately reflect the material toughness in various real-world conditions, leading to overly conservative assessments that require material toughness. To tackle this issue, this project was launched in December 2022 to refine the application of MegaRule RIN 1—192.712. It proposed a tailored approach across three material categories: vintage base metal, Double Submerged Arc Welded (DSAW), and the Heat- Affected-Zone (HAZ) of Electric Resistance Weld (ERW)/Electric Fusion Weld (EFW), including some ERW fusion lines. The project delineated three analysis levels for each category based on available data: no data, some Charpy data, and both Charpy and traditional fracture mechanics test data. By Q3 2024, the final project report was successfully completed/approved. This initiative will soon equip PG&E and other operators with scientifically grounded, practical guidelines for implementing the Mega Rule requirements. These guidelines are designed to reduce inefficiencies and costs while maintaining safety standards.

Co-Funders: PRCI members

Start Date: 12/12/2022
End Date: 7/2/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$249,995
Total PG&E Cost:	$1
Total Co-Funding:	$249,994

Benefits

IM-3-03 Comprehensive Review of SSWC Assessment

This Pipeline Research Council International (PRCI) Crack Management Strategic Research Priority (SRP) Project will perform a comprehensive review of previous work done in the industry and the current approaches to selective seam weld corrosion (SSWC) and look for a path for assessing the reported SSWC features. These new directions are formulated to overcome the inherent shortcomings in the current approaches. With the completion of this work, the PRCI Crack Management SRP will close the identified gaps related to how SSWC should be assessed via fracture mechanics models. The team will start by reviewing how the industry got to where it is, evaluating SSWC as a crack, and providing a path to gap closure. A critical evaluation of the current approaches should lead to understanding their limitations. The project kicked off in June 2023 and completed Task 1 (Review of Past Analysis on SSWC Incidents),Task 2 (Further Review and Analysis of SSWC Incidents) and Task 3 (New Direction) by Q3 2024. The draft final report has been delivered in Q4 2024 and is expected to go though some revision till final approval in Q1 2025. Upon completion, the work will produce recommendations for assessing SSWC with these limitations in mind. The new directions identified in the project would lead to significant improvements in managing SSWC, which should help PG&E and other operators make cost-effective decisions about how they approach SSWC, including satisfying regulatory requirements.

Co-Funders: PRCI members

Start Date: 6/12/2023
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$100,000
Total PG&E Cost:	$1,920
Total Co-Funding:	$98,080

Benefits

Investigation of EddyFi's Eddy Current NDE Tool for Hard Spots

This work is to develop hard spot screening as part of standard H-form process at PG&E, including rapid detection of pipeline hard spots at integrity inspection sites. The project is conducted by non-destructive exam (NDE) team at PG&E Advanced Technology Service (ATS) Center using the existing EddyFi's eddy current tools with strong technical support from a PG&E's contractor who has been developing hard spot inspection and management program for PG&E Transmission Pipeline Integrity Management Program. This work aligns with PG&E's decarbonization goals, as hydrogen can easily cause cracking at hard spots. Detection and characterization of all the hard spots in the pipeline is an important task to make sure the risk of H_2 cracking is minimized. By Q4 2024, the EddyFi Field Implementation Procedure draft as well as TD-4810P-18 TIMP Direct Examination Procedure draft have been completed and approval for field deployment is expected by Q1 2025 to support the scheduled ILI Dig in Q1 2025.

Co-Funders: N/A

Start Date: 5/1/2024
End Date: 12/31/2024
Status: Completed

2024 Funds Expended:	$86,232
Total Project Cost:	$141,400
Total PG&E Cost:	$81,000
Total Co-Funding:	$60,400

Benefits

JCAS-01 Pipeline Integrity Tool Cloud-Based Assessment Software

This project is to develop an improved version of the PRCI MAT-8 model for seam weld anomalies by incorporating a new probabilistic approach that include ILI tool performance characterization (probability of detection (POF), probability of identification (POI) and sizing). This will solves the issues associated with newly released PHMSA requirements in 49 CFR 192.607 (Verification of Pipeline Material Properties and Attributes: Onshore steel transmission pipelines); 192.632 (Engineering Critical Assessment for Maximum Allowable Operating Pressure Reconfirmation: Onshore steel transmission pipelines); and 192.712 (Analysis of Predicted Failure Pressure). The probabilistic models and algorithms apply the best available fracture mechanics technology to the seam weld cracking threat. New innovations have been introduced, including accounting for the difference between real-world seam anomalies and ideal cracks. The probabilistic framework is a vastly improved decision tool for integrity management. Traditional rules-based approaches for making dig/repair decisions following an ILI tool run contain a high degree of subjectivity, but the new probabilistic approach presents an objective means to prioritize and quantify threats. The output of a probabilistic analysis can be coupled with financial models to optimize both reliability and profitability. By August 2024, the framework is delivered as a cloud-based software app per the original scopes that: 1) implements a probabilistic version of the new PRCI MAT-8 model; 2) evaluates mitigation: hydrostatic pressure tests, pressure reductions, future in-line inspections; 3) uses cloud computing to speed up calculation time. It also has built up a very comprehensive database of vintage pipe fracture toughness in the industry that immediately benefits all the participating members by saving millions of dollars. From August to December 2024, an extension of the original scopes was executed for some further improvement.

Co-Funders: PRCI JIP members

Start Date: 4/22/2020
End Date: 8/31/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$679,000
Total PG&E Cost:	$47,245
Total Co-Funding:	$631,755

Benefits

JIP—Development of New Fracture Mechanics Features in APTITUDE

This industry joint project is to further develop and enhance Structural Integrity's APTITUDE™ fracture mechanics tools that include the following tasks: Task-1 Development of a web-based APTITUDE application; Task-2 Hard Spot Module updates; Task-3 Probabilistic Analysis Tools for Hard Spot and SCC; Task-4 Incorporation of a Fatigue Crack Growth model for Hydrogen blending; Task-5 Rainflow Calculator Tool; Task 6 Fracture Mechanics Training; Task-7 Four quarterly crack management workshop sessions. This project with 4–5 operator participants started in 5/2024 and expect to complete by April 2025. By end of 2024, it completed: 1) 3 quarterly crack management workshops; 2) Basic Web Application Deployment/Code integration test; 3) Basic Modules (PFP Calculator/ Large Analysis) pushed to production server for user trials and feedback. The remaining tasks to be completed in 2025 include: 1) Advanced Modules; 2) The 4th quarterly crack management workshop and final project delivery. Upon successful completion of the work, PG&E will have additional fracture mechanics assessment capabilities for fitness for service application that is used for Gas Transmission Engineering, along with perpetual license, which is expected to greatly improve the pipeline integrity management O&M Safety and Efficiency at reducing cost. It will also greatly benefit the decarbonization efforts by incorporating a fatigue crack growth model for hydrogen blends.

Co-Funders: Williams, Duke-Energy, National Grid, SoCal Gas, Dominion, Enbridge

Start Date: 5/21/2024
End Date: 4/30/2025
Status: Active

2024 Funds Expended:	$30,927
Total Project Cost:	$0
Total PG&E Cost:	$29,750
Total Co-Funding:	-$29,750

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

M2014-001 Ph 3 JPL Methane Detector and Control System for sUAS Technology

It is important to stay up to date with new leak detection technology. This project works to advance the sUAS technology for leak survey already established for methane detection capability and ground emission location accuracy. Additionally, it will work to develop methane emission quantification. Ph III intended to improve ground localization of methane and to improve the quantification algorithm that has been underway since 2020. Drone testing at all 3 proposed locations including PG&E territory was completed in 2023. A final report by JPL is currently underway that will provide a thorough data analysis and takeaways from the project.

Co-Funders: National Grid, National Fuel Gas Distribution Corporation, New York State Electric & Gas Corporation & Rochester Gas & Electric, Orange & Rockland Utilities, Inc., Baltimore Gas & Electric Company, PG&E, Southern California Gas Company

Start Date: 11/3/2020
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$338,140
Total PG&E Cost:	$67,630
Total Co-Funding:	$270,510

Benefits

M2016-002 Ph2 Odor Detection Threshold Study

The final report was issued on March 31, 2024. The objective of the project was to understand how the introduction of conditional factors of odor adaptation and odor-masking agents affect the detection and recognition thresholds of natural gas odorants. Phase 2 of this natural gas odor detection threshold study used the odorant thresholds of human detection levels determined in Phase 1 as a reference. The team studied odor masking effects and odor adaptation effects in parallel, but results were provided independently to understand each variable's effects better. The project team reviewed the odor-masking effects of d-limonene and ammonia. D-limonene is a common chemical found in housecleaning products. Ammonia was also studied because it is a chemical found in renewable natural gas. The results of the masking portion of the project determined that d-limonene or ammonia did not display a masking effect on natural gas odorants. The project also investigated the self-adaptation effects of odorants where exposure to the odorant reduced the ability to detect odorants in gas leaks. This adaptation study determined that pre-exposure does decrease a person's ability to detect and recognize an odorized natural gas. This project will help PG&E identify risks associated with odor masking components and validate previous studies on the effects of adaptation to meet the safety standards for employees and customers.

Co-Funders: SoCalGas, NYSEARCH members

Start Date: 10/1/2019
End Date: 3/31/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$1,281,783
Total PG&E Cost:	$117,405
Total Co-Funding:	$1,164,378

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

M2017-004 Ph3 Methane Oxidation Catalysts to Replace Flaring

The project seeks to develop materials that oxidize hydrocarbons at low temperatures via a catalytic process. If a proof-of-concept device could be procured, it could eventually be scaled up to replace flaring units. This is important to PG&E as it could be deployed in cities and on sites where flaring is not permitted, but abatement of relatively small volumes of natural gas is needed. In Phase 1, Stanford University improved the activity of palladium (Pd) catalysts by ten times relative to commercial Pd-based catalysts and explored the influence of water on combustion rates. In Phase 2, the Stanford team tested the results under realistic conditions and designed a lab prototype to show proof-of-concept of the champion catalyst system's performance. Phase 3 is focused on large-scale feasibility, cost/benefit analysis, unit fabrication, and performance verification. NYSEARCH, the Questor team, and the Stanford professor who pioneered this research presented a status report in March 2024 that updated the oxidizer prototype design.

Co-Funders: Central Hudson Gas & Electric Corporation, National Grid KSP and National Grid-NMPC, National Fuel Gas Distribution Corporation, New York State Electric & Gas Corp. and Rochester Gas & Electric Corp., PG&E, Atlanta Gas Light Company

Start Date: 1/1/2021
End Date: 9/30/2026
Status: Active

2024 Funds Expended:	**$7,783**
Total Project Cost:	**$238,122**
Total PG&E Cost:	**$39,155**
Total Co-Funding:	**$198,967**

Benefits

M2019-004 Ph2 Development of Mercaptan Sensor Systems with Non-Radioactive Ionizer Phase II

The project was completed on March 31, 2024 and aimed to advance the sensor performance of a portable mercaptan sensor that can serve as an in-line quantification tool to replace sniffing checks and for use as a 'smart nose' in mobile applications to detect mercaptans accurately. The project team delivered and tested a pre-commercial prototype for PG&E, which requested further enhancement. The version of the device presented herein is the best performing thus far with improved repeatability, durability, and dependability relative to previous designs. The UC Davis team strongly feels the technology is ready to advance into commercialization. Considering UC Davis' exhaustive efforts to remedy the detector manufacturing issues, a specialized manufacturer must be identified for this sole component for commercialization. A successful commercialization outcome for this project would result in a new, marketable technology that would allow PG&E, for the first time, to measure the concentrations of mercaptans at levels comparable to those of the human nose.

Co-Funders: PHMSA, NYSEARCH members

Start Date: 9/21/2021
End Date: 3/31/2024
Status: Completed

2024 Funds Expended:	**$0**
Total Project Cost:	**$923,147**
Total PG&E Cost:	**$49,610**
Total Co-Funding:	**$873,537**

Benefits

M2019-010 PhII Eclipse Scientific Red/Green Light NDE Tool for PE Butt Fusion Joints

The project aims to develop an automated non-destructive examination (NDE) tool that does not require operators with specialized training in NDE to inspect the integrity of butt-fusion (BF) joints. Pipe fusers can join polyethylene (PE) pipes by melting both ends and forcing the ends together to form a BF joint. The integrity of the BF joint is essential for long-term performance. NYSEARCH members have invested considerable resources into NDE development for PE pipe through extensive testing with The Welding Institute. Eclipse Scientific has developed the automated NDE constructs of pass/fail (green/red) for performing PE pipe joint interrogation. This project received a portion of the defective BF joint samples developed under NYSEARCH Project M2019-009 and completed scans of standard and faulty joints to continue the integration of automated defect recognition. A comprehensive set of samples featuring simulated lack of fusion (aluminum disks), oil/grease contamination, coarse and fine particulate contamination, and cold fusion flaws were scanned and analyzed using an optimized projection-focused, phased-array technique designed for the inspection of medium-density-PE and high-density-PE BF joints. The results indicated that all common joint flaws can be detected using the prototype system and that features present in flawed samples can be readily isolated and used to train a machine-learning algorithm to detect these defects. By November 2024, this Phase II was successfully completed. The next phase is development of a complete inspection program and commercialization of the inspection system (hardware and software) for integration into in-field post-welding quality control of PE butt fusion joints. The successful development of this technology can improve the integrity of BF joints constructed by PG&E since any defect in the joint would be identified before placing the pipe into service. PG&E will utilize the knowledge gained in this project for possible in-house evaluations when a prototype is available.

Co-Funders: NYSEARCH members

Start Date: 7/25/2022
End Date: 11/11/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$442,000
Total PG&E Cost:	$77,000
Total Co-Funding:	$365,000

Benefits

M2020-006 Standardization of NYSEARCH Methane Emissions Validation Process

The objective of the project is to identify, apply, and test a methodology or set of methods that enable a gas distribution operator to validate the accuracy of measuring, locating, and quantifying the methane emissions rate from non-hazardous natural gas infrastructure leaks. Non-hazardous leak indications (Grade 3) are given a lower priority from a safety perspective and can be monitored rather than scheduled for repair. By adding a process for validating methane emissions, gas company operators and their constituents can prioritize the environmental impact of Grade 3 leaks. Once this work is completed, this methodology can be standardized. The latest update of the project included NYSEARCH, P-Pic and AGA holding a discussion where AGA agreed to ask AGA sub-committees for advisement on this project's intended approach. AGA recommended ASTM for standardization. GTI took the lead after P-Pic departed and is developing a rough ASTM draft to be submitted to the ASTM subcommittee.

Co-Funders: Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, Inc., National Grid KSP and National Grid-NMPC, National Fuel Gas Distribution Corporation, PG&E, Southern California Gas Company, Southwest Gas Company, Spire–Alabama

Start Date: 6/30/2020
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$71,820
Total PG&E Cost:	$9,265
Total Co-Funding:	$62,555

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

M2021-002 Ph3 sUAS (Drone) Inspection for Submerged Pipes, Ph III

The overall objective of this project is to further develop drone technology to perform enhanced leak detection surveys and mechanical integrity inspections for difficult to access suspended pipe and submerged pipelines. The objective of Phase III is to advance, optimize, and finalize the development of the inspection platforms, sensors, and operating procedures. The project team will visit and test at several sites in funders' territories for final test and modifications to the hardware, software and operating instruments. A final report will detail the required bases for conducting a gas asset survey and inspection. If successful, PG&E can benefit from using small remotely controlled platforms with adaptive sensors for routine and emergency surveys and inspections for submerged gas pipelines.

Co-Funders: NYSEARCH members

Start Date: 1/18/2024
End Date: 12/19/2025
Status: Active

2024 Funds Expended:	$18,880
Total Project Cost:	$209,050
Total PG&E Cost:	$18,880
Total Co-Funding:	$190,170

Benefits

M2021-004 Electromagnetic Time Domain Reflectometry (EM-TDR) for Pipeline Integrity

The objective of the project is to perform an initial feasibility evaluation, numerical modeling, system benchtop prototyping, and performance evaluation for Electromagnetic Time Domain Reflectometry (EM-TDR) for inspecting transmission natural gas pipelines. EM-TDR is a mature technique developed to identify and locate faults in metallic cables. Lawrence Berkeley National Lab proposes applying this technique within the natural gas industry. Previously, the project team completed the initial feasibility evaluation and numerical modeling, and the project passed the Go/No Go milestone. In 2023, the team tested the full-scale engineering prototype on buried and aboveground pipes with known defects. The team analyzes test results and compares them to a database of the actual pipe defects. The results will be used to complete numerical simulations for a second field trial in early 2024. This study provides information on the ability to obtain more data on difficult-to-access pipeline portions currently assessed by External Corrosion Direct Assessment (ECDA). EM-TDR could be used to further evaluate carrier pipes within cased segments and crossings where ECDA techniques are unavailable. PG&E could use this tool to supplement and enhance its existing ECDA inspection techniques supporting the pipeline integrity program, which further reinforces the safety and reliability of its pipeline network infrastructure. This project was completed in March 2024 with some positive and negative outcomes. But in general the technology is still in its early stage of development for pipeline applications and requires lots of follow-up work before it can be reliably used for field work.

Co-Funders: NYSEARCH members

Start Date: 10/1/2021
End Date: 3/31/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$339,000
Total PG&E Cost:	$28,850
Total Co-Funding:	$310,150

Benefits

M2021-006 Ph3 Explorer Wireless Range Extender

The NYSEARCH Explorer Inspection Robot Program has achieved the following goals: 1) developed a full range of Explorer platforms; 2) developed a suite of sensors able to detect corrosion defects, cracks, and mechanical damage; 3) developed a system to provide additional power to the robot via energy harvesting methods. The Program now focuses on extending the range of the wireless system used on the robots. Following the success of the Phase 2 work—This is the last known barrier to long-range operations, significantly higher operational efficiencies, reduced inspection costs, and lower-risk inspections. Following success of Phase 2 work on design and build of a lab prototype system including new Eeo-based wireless communication system, this Phase 3 work focuses on field testing the technology of to extend the range of the wireless communication system on Explorer robots with delivery of a project report and a field-ready prototype for commercialization. It includes two field trials. The first was carried out at a NYSEARCH Test Bed (Johnson City, NY), and the second in a pipeline operated by a funding company. The project is organized into three tasks: Task 1—Deploying Explorer 20-inch tool in Open Pipeline at the NYSEARCH Test Bed to verify the reliable and robust operation of the entire system; Task 2—System Updates, the lessons learned from the field deployment in Task 1 are implemented on the system by adopting necessary changes in the design and functionality of the system; Task 3—Testing in a Real Pipeline will involve the deployment of Explorer 20/26 in a real pipeline (preferably not in operation) to initiate and operate the system as part of a commercial endeavor, incorporating multiple Remote Earth Modules (REMs) for comprehensive performance assessment. The project kicked off in November 2023 and completed the field-ready prototype by Q3 2024. The next step is to conduct the field test through a commercial field inspection project by Q1 2025. Upon success of this field testing, the field-ready prototype can be advanced to commercialization.

Co-Funders: NYSEARCH members

Start Date: 11/1/2023
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	**$16,647**
Total Project Cost:	**$194,388**
Total PG&E Cost:	**$23,565**
Total Co-Funding:	**$170,823**

Benefits

M2021-009 Feasibility Study on High Resolution MFL for Explorer Series of Robotic Platforms

This NYSEARCH Project is to conduct a feasibility study on integrating a high-resolution magnetic flux leakage (MFL) sensor onto the Explorer robot platform, assess multiple commercially available sensors, and optimize the resulting system for maximum efficiency and interchangeability among the various robots. This project has four tasks: 1) determine the best sensor for the application while considering potential solutions to implementation issues (i.e., sensor control, data transfer); 2) identify various concepts for sensor positioning and design schemes, and select the best one; 3) build a benchtop prototype system based on the design selected to validate optimal integration into the magnetic bars and performance (data collection and transfer, sensor resolution, defect sizing resolution, etc.); 4) summarize the results with a recommendation for implementing the new sensors on the MFL module. In early 2022, the project team began the feasibility study for building and testing a proof-of-concept prototype. In 2023, the project was delayed due to resource constraints. By End of 2024, this feasibility work was successfully completed with delivery of a benchtop prototype system, a feasibility analysis draft report and recommendations for the next steps. The next step is to develop and test the high resolution MFL system for the Explorer 20 robot from 2025. Improving the sensor capabilities of the Explorer family of robotic platforms will benefit the PG&E In-line Inspection program for unpiggable pipelines because smaller sensors will enable higher spatial and circumferential resolution and detectability of more minor defects with higher resolution. As a result, PG&E and other operators will have higher confidence levels in obtained measurements.

Co-Funders: PHMSA members

Start Date: 4/30/2021
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$215,084**
Total PG&E Cost:	**$23,900**
Total Co-Funding:	**$191,184**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

M2021-011 A Feasibility Study on Extending Energy Harvesting to Other Pipetel Explorer Sizes

The objective of the project is to perform a feasibility study on the scalability of the Explorer 20/26 Energy Harvesting (EH) system—equipped to function within 20"– 26" diameter pipe—to other platforms and precisely to determine the performance envelope for the Explorer 10/14, 16/18, and 30/36 within 10"–14," 16"–18," and 30"–36" diameter pipe, respectively. The team will analyze the robots' power consumption and tow force under various operational conditions and their ability to generate energy for themselves within different pipe sizes. The team will also investigate the mechanical design of the EH system and its impact on the overall weight of the robots, quantify the power and energy generated for different pipe sizes under different operating conditions, and modify the EH system's electronics, if necessary. It will also explore the potential impacts of the EH technology in its commercial deployment across various Explorer robot platforms. The team will deliver a report outlining the tasks conducted during the feasibility study. This report will include: 1) key parameters for an EH system for different pipe sizes of the Explorer fleet; 2) remedies for technical obstacles that EH systems need to overcome to be successfully developed in future phases; and 3) recommendations on the next steps. In 2023, the project resumed work and began an analysis of the power consumption and tow force of the robots in various pipe sizes and conditions. By Q4 2024, all the tasks have been completed with positive outcomes except the final draft report expected by Q1 2025. This project will provide technical directions to expand the inspection capabilities of the Explorer robotic tools and enable the PG&E in-line inspection program to collect more data and conduct longer inspections.

Co-Funders: NYSEARCH members

Start Date: 4/30/2021
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$193,948
Total PG&E Cost:	$19,395
Total Co-Funding:	$174,553

Benefits

M2023-003 Optimal Design and Operation of Soil Aeration Systems for Belowground Natural Gas Mitigati

The objective of this project is to use numerical models, analytic methods and controlled and field testing to investigate the feasibility of developing a practical approach for design, operation and monitoring of site-specific soil aeration systems. The project team will visit and test at several sites in funders' territories to validate the expected reduction in gas concentration and time to complete in the field. The results of the field tests will be provided in a final report. If successful, an optimized site-specific method for soil aeration would improve safety at PG&E by clearing underground emissions faster, clear leaks that could remain near buildings, and reduce repeat site visits and monitoring.

Co-Funders: SoCalGas, NYSEARCH members

Start Date: 2/13/2024
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$37,410
Total Project Cost:	$261,853
Total PG&E Cost:	$37,410
Total Co-Funding:	$224,443

Benefits

M2024-002 Bakhtar License and Tech Transfer Investigation

Bakhtar Research and Engineering LLC (BR&E) with funding from the California Energy Commission (CEC) and the US Department of Transportation (USDOT), has demonstrated that their Bakhtar Pipe Detector (BPD) is able to detect underground plastic pipes under certain conditions. While NYSEARCH should pursue a project to complete the development of an engineering prototype, that should not happen before a patent is prepared and before a license to commercialize the technology is secured. Also additional financial resources need to be allocated to support this effort, given that the anticipated NYSEARCH staff and support personnel (contracts and legal) resources would typically not be reimbursable until an R&D project contract was executed and invoices from the contractor were received. This project is to negotiate a license agreement with Bakhtar Research and Engineering LLC (BR&E) for the underground pipe detection technology under development by the company and the preparation of a patent to cover this technology.

Co-Funders: NYSEARCH members

Start Date: 10/1/2024
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$13,045
Total Project Cost:	$75,000
Total PG&E Cost:	$75,000
Total Co-Funding:	$0

Benefits

MAT-1-09 Guidance for Traceable Verifiable and Complete Documents

Material properties and attributes are required to support the maximum allowed operating pressure (MAOP) and manage the integrity of the pipeline. Records that document material properties and attributes, and pressure test must meet the definition of 'Traceable, Verifiable, and Complete' (TVC) per regulation (49 CFR 192). This Pipeline Research Council International (PRCI) project is to establish a consensus interpretation of TVC requirements that can be used as a foundational basis for operators and vendors. 3 Tasks are included: 1) Review Drivers and Current Regulations; 2) Gather and Review Industry Approaches; 3) Compile and Document Aligned Intent, Definitions, and Approaches. The project was kicked off in Q2 2024 and is expected to complete by Q2 2025. Upon successful completion, PG&E will get the industry consensus guidance of TVC document requirements to improve the existing procedures to more efficiently and cost-effectively conduct record verification by eliminating misidentification of records or minimizing high-cost excavation with material testing or pressure testing.

Co-Funders: Project operator members

Start Date: 6/25/2024
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$236,000
Total PG&E Cost:	$9,516
Total Co-Funding:	$226,484

Benefits

MAT-1-8 Post-Heating and Interpass Control as an Alternative to Delayed Nondestructive Examination

The project will define weld procedure parameters that may be used to ensure sufficient hydrogen effusion and mitigate the risk of hydrogen cracking for Shielded Metal Arc Welding (SMAW) in-service fillet weld (Phase I) and SMAW girth weld production/tie-in (Phase II) procedures. The produced guidance will cover demonstrated weld time to peak hydrogen, the time after which hydrogen cracking should not commence, and general information on which parameters are most effective in controlling inspection delay time. Users can compare their welding procedure to the developed guidance and identify minimum recommended inspection delay times or post-heating and develop recommended welding procedure parameters that may be used to reduce inspection delay time while ensuring that hydrogen cracks do not enter service. This, in turn, will increase efficiency by reducing costs and improving safety for SMAW weld procedures. After the project kickoff in June 2023, the team identified pipe, sleeve, welding parameters, and weld geometries to encompass applications of interest to Pipeline Research Council International members. The team also identified electrodes of interest, developed electrode handling recommendations, and completed hydrogen effusion testing. By end of November 2024, all the hydrogen diffusion models are completed and verified. Draft final report has been delivered fir review on in December 2024. The project is on track to completion by Q1 2025. The weld inspection delay of 12 to 48 hours can be eliminated or reduced upon project completion. This will benefit PG&E and other operators by improving field operation efficiency (reducing cost and increasing safety) for SMAW weld procedures.

Co-Funders: PRCI members

Start Date: 6/8/2023
End Date: 4/30/2025
Status: Active

2024 Funds Expended:	**$938**
Total Project Cost:	**$224,200**
Total PG&E Cost:	**$20,000**
Total Co-Funding:	**$204,200**

Benefits

MAT-7-2 Hard Spot Susceptibility Review—Pipe Manufacturers, Pipe Type, Vintage

The PRCI Crack Management Strategic Research Priority (SRP) Project aims to develop guidelines to support operators who need to assess when an in-line inspection (ILI) survey for detection of hard spots should be performed. Additionally, as the industry pursues the energy transition, hydrogen-induced cracking (HIC) and hydrogen-assisted cracking (HAC) will become more paramount as they relate to hard spots in vintage steel. The specific guidelines to be developed will be required to align with the American Petroleum Institute Recommended Practice 1176, Assessment and Management of Cracking in Pipelines. This 12-month project began in April 2023, with the project team completing compilation of hard spot cooling rates and hard spots per mile by pipe manufacturers from ILI data. The team initiated the development of a prioritization scheme and the next step is to complete the a decision and prioritization process. The project has been completed in July 2024 with the issuing of the final report. PG&E and other operators are now able to reference the guideline to determine whether a hard spot ILI assessment is required. By understanding where the hard spot threats are most likely to be and targeting ILI activities at those locations, PG&E and the industry will more rapidly identify hard spots and implement mitigation strategies in more efficiently and effectively.

Co-Funders: PRCI members

Start Date: 4/8/2023
End Date: 7/10/2024
Status: Completed

2024 Funds Expended:	**$0**
Total Project Cost:	**$150,000**
Total PG&E Cost:	**$2,820**
Total Co-Funding:	**$147,180**

Benefits

MAT-7-2A New Multi-Year Project: Hard Spot Detection

This three-phase project seeks to develop improved pipe material hard spot detection/sizing in response to the National Transportation Safety Board (NTSB) report NTSB/PIR-22/02 re: Danville, Kentucky. The project builds on the Pipeline Research Council International (PRCI) MAT-7-2 Hard Spot Susceptibility Review project results. Phase 1 will focus on building a more robust framework for hard spot management through gap analysis. Phase 2 will focus on evaluating the performance of currently commercialized hard spot in-line inspection (ILI) tools and identifying the areas for improvement associated with both the tools and analysis. Phase III will run a machine learning model of inputs reviewed in phases I and II to enhance operator guidance. After the kick-off in September 2023, the project team prepared the test pipe samples for a non-destructive exam (NDE) at the PRCI Technology Development Center in mid-December. In 2024, ILI pull-test at PRCI Technology Development Center with 6 vendors were completed and the ILI performance analysis is on track to completion by early January 2025. The draft final project report is expected for review by end of January 2025. Upon successful completion, this work will provide PG&E and other operators with integrity management tools for hard spots. The work will also be instrumental in preparing operators for the likely upcoming Pipeline and Hazardous Materials Safety Administration advisory bulletin regarding hard spots. In addition, the work will help future hydrogen projects as hydrogen is a significant contributor to hard spot incidents.

Co-Funders: PRCI members

Start Date: 9/11/2023
End Date: 2/28/2025
Status: Active

2024 Funds Expended:	**$1,660**
Total Project Cost:	**$848,391**
Total PG&E Cost:	**$25,614**
Total Co-Funding:	**$822,777**

Benefits

MAT-8-3C Understanding Why Crack Fail—Results Sharing

Pipeline Research Council Internation (PRCI) Crack Management Strategic Research Program (SRP) will both further understanding of cracking in pipelines and allow the convergence of multiple PRCI research projects. One of the key goals of the Crack Management SRP is to "further operationalize the TDC and VTDC for crack management." This Crack Management SRP project will develop a location within the VTDC to store the lessons learned from the failures so that PRCI members can access the information for future risk management. This project started on May 1, 2023, and is expected to be completed in Q3 2024. The scope of work includes: Task-1 Review the results and spreadsheet of incident root causes developed in MAT-8-3; Task-2 Remove any incidents that operators do not want to share; Task-3 Identify any new or helpful information that needs to be collected (e.g. %SMYS, distance to pump/compressor station, distance to rectifier, etc.); Task-4 Collect new information from operators; Task-5 Develop an input template for the VTDC to collect future information and a method to review in the future; Task-6 Review incidents with operators to ensure they are sufficiently sanitized; Task-7 Put results into the Virtual Technology Development Center (VTDC). With the completion of this work, the Crack Management SRP will make progress in operationalizing the VTDC with a new data set that can be used to learn from previous incidents and near misses. PG&E can use it as a good additional data resource (pipe specifications, cracking susceptibility, root cause, assessment, remediation, etc.) to more cost-effectively manage the transmission pipeline crack integrity management program.

Co-Funders: PRCI members

Start Date: 5/1/2023
End Date: 7/16/2024
Status: Completed

2024 Funds Expended:	**$0**
Total Project Cost:	**$37,000**
Total PG&E Cost:	**$934**
Total Co-Funding:	**$36,066**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

MD-2-4 SRP MD Improvement to Mechanical Damage Engineering Assessment Tools

The project aimed to improve Mechanical Damage (MD) tools, which to date include approximations and conservatism to ensure pipeline safety. This Pipeline Research Council Internal (PRCI) project harnessed existing dig, operational, ILI, and failure event data for the enhancement of existing assessment tools. By taking the result of field data review and pull trials to update and modify conservatism in tools, better prediction of the threats posed by operations, dent and coincident features on pipeline integrity are achieved. The project was kicked off in Q3 2022, better focused on remedial action, and reduced failures and unnecessary maintenance. By Q3 2024, this work was successfully completed with the knowledge-transfer webinar in Q4 2024. Through optimization of PG&E and other operators' maintenance programs focusing resources on the true threats to pipeline integrity and eliminating excavations that are unnecessary, this work is expected to improve the existing MD integrity management tools to improve safety and performance at a reduced cost.

Co-Funders: PRCI members

Start Date: 7/19/2022
End Date: 8/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$354,000
Total PG&E Cost:	$5,767
Total Co-Funding:	$348,233

Benefits

MSA Leak Prevention—Jomar Male Tailpiece

Meter set leaks are among the top emitters in PG&E territory, making meter set leak prevention a high priority for PG&E. The purpose of this project is to test the Jomar male tailpiece to determine if it can be used to prevent meter set leaks from occurring. Most above-ground meter set leaks occur below the regulator on the nipple. Jomar manufactures a male tailpiece for their insulated meter valves. If this component were used instead of the current state of the art, the number of threaded connections would be reduced by 50%, resulting in 50% fewer potential leak points. The project was kicked off in Q1 2024 and is expected to be completed in Q4 2024, with a final deliverable being an internal analysis by the PG&E M&P team.

Co-Funders: N/A

Start Date: 2/26/2024
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$15,000
Total PG&E Cost:	$15,000
Total Co-Funding:	$0

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

NDE-2-15 SSWC Identification, Sizing, and Measuring Grooving Ratio in the Ditch

This Pipeline Research Council Internation (PRCI) project's main task is to develop in-the-ditch evaluation methods and necessary tools to identify external selective seam weld corrosion (SSWC) verses other defects such as lack of fusion or seam trim and measure external SSWC depth and length. Outline pros and cons for each method. Relevant seam types for the main and sub-tasks are DSAW (Double Submerged Arc Welding), SSAW (Spiral Submerged Arc Welding), EFW (Electrical Fusion Welding), and ERW (Electrical Resistance Welding): Subtask-1 Develop a method for measuring grooving ratio using the grooving ratio definition provided in PRCI project EC-2-12 (SSWC Identification, sizing, and measuring grooving ratio in the ditch) for external SSWC; Subtask-2 Determine which interaction rules apply for external SSWC; Subtask-3 Explain the differences in SSWC morphology for different seam weld types in liquid vs. gas service; Subtask-4 Justify the appropriate assessment model (notch vs. crack) using results in IM-03-03 (Comprehensive Review and Assessment Guidelines for SSWC) based on the morphology found in the ditch. This project was kicked off in October 2023 and made actively progress in conducting various NDE characterization of the field samples and verifying the NDE data by destructive testing of some of the samples. By Q4 2024, all the works have been successfully completed except that the draft final report is still int he process of the minor revision. Upon successful completion as expected in Q1 2025, this project will provide PG&E and other operators guidelines for positive identification of SSWC and proper measuring equipment and techniques for in-the-ditch: 1) Guidelines for measuring grooving ratio following the guidance in EC-2-12; 2) SSWC interaction rules; 3) SSWC morphology for different seam types in liquid/gas pipelines; 4) Guidelines for choosing the appropriate assessment model (notch vs. crack) using results of IM-3-03 based on the morphology found in the ditch. These will help significant improvement of the cost-effective assessment and mitigation of the SSWC anomalies. Next step is to write the final report, expected to be published Q3 2025.

Co-Funders: PHMSA members

Start Date: 10/16/2023
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$325,000
Total PG&E Cost:	$25,180
Total Co-Funding:	$299,820

Benefits

NDE-3-6 Review and Evaluation of Pipe Stress Inspection Techniques for Onshore Pipelines

The project will provide a comprehensive review, an operation manual, and a guideline document for all the known pipeline stress/strain detection technologies, including in-line inspection (ILI) technologies, in-the-ditch stress detection, and above-ground screening/estimation. The final goal is to understand better available technologies and their viable deployment in the field. This will complement the current mainstream inspection practices that mainly rely on anomaly geometry-based detection/characterization and have a low probability of detection/characterization or inaccurate sizing for crack-like challenging anomalies, resulting in unnecessary costly ILI or excavation. The project kicked off in Q3 2022. The revised draft of the Literature Review Report is expected for final revision/approval in Q1 2025. All the lab and field tasks and modeling work have been completed by Q4 2024, with targeted delivery of draft final project in Q1 2025. Upon successful completion, this work will also deliver an analysis report on the characteristics and applicability of different stress-detection technologies and original macro stress test raw data obtained from various equipment under different working conditions at the field sites at PipeChina, an overseas Chinese pipeline operator. These documents will allow PG&E and other operators to understand the field's design focus, parameter requirements, and use of the detection equipment guide. Based on the testing methodology and shared parameters/data from this project, PG&E, and other operators will be able to compare indicators of existing equipment and optimize or further improve the equipment, leading to significant cost benefits.

Co-Funders: PRCI members

Start Date: 11/8/2022
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$237,000
Total PG&E Cost:	$20,000
Total Co-Funding:	$217,000

Benefits

NDE-4-12 Continuous Improvement of ILI Capabilities

The American Petroleum Institute and Association of Oil Pipe Lines's R&D Work Group and Pipeline Research Council International (PRCI) are undertaking a Joint Industry Project to develop pull test strings and protocols to validate and test the performance specifications published for various crack in-line inspection (ILI) tools. As part of the PRCI Crack Management Strategic Research Priority Program, this project continuously leverages three well-known engineering firms' existing expertise in ILI crack technologies, deep knowledge of crack defects and their growth mechanisms, laboratory capabilities, and experience performing metallurgical analysis and defect characterization. By end of 2024, the project team completed all the ILI tool pull testing work at the PRCI Technology Development Center in Houston, Texas, ILI data analysis, Non-Destructive Examination (NDE) flow profile characterization, progress in ILI-NDE data alignment. Due to some technical difficulties, quantifying the ILI tool accuracy (tolerance) as a function of the field NDE measurements is still in process. The overall project completion timeline is delayed to Q1 2025. Once completed, this work will help PG&E and other operators identify and address the underlying physics-based reasons why cracks are hard to detect, identify, and size. It will support PG&E in conducting fair, unbiased, and accurate assessments of the current commercial ILI crack detection capabilities, thus ensuring sound and defendable decisions regarding cost-effective crack management.

Co-Funders: PRCI members

Start Date: 12/12/2019
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,287,010
Total PG&E Cost:	$21,740
Total Co-Funding:	$1,265,270

Benefits

NDE-4-13 Selective Seam Weld Corrosion Detection with In-line Inspection Technologies

The objective of the project is to evaluate and validate magnetic flux leakage (MFL) technologies currently in use by in-line inspection (ILI) vendors for detecting selective seam weld corrosion (SSWC). SSWC is a type of corrosion that affects the bond-line region and heat-affected zone of the longitudinal seam of a pipeline, forming grooves in the seam. Circumferential MFL technologies can detect the long-seam weld position and accurately detect the presence of corrosion on the long seam. However, these MFL tools generally cannot differentiate between SSWC and coincidental corrosion. As technologies and analysis processes have improved, ILI vendors can better detect SSWC. The project will provide pipeline operators with up-to-date knowledge about ILI capabilities to detect SSWC and differentiate it from coincidental corrosion interacting with the long seam weld. This knowledge will help them make informed decisions about managing pipelines with SSWC or corrosion. By December 2024, all the ILI Pull Tests were completed. ILI performance analysis and draft final project report are on track to completion by Q1 2025. Upon successful completion of the project, PG&E can use the results and identified ILI tools to more accurately detect SSWC in its pipelines, improving safety and reliability.

Co-Funders: PRCI members

Start Date: 7/27/2020
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$1,588
Total Project Cost:	$811,500
Total PG&E Cost:	$39,137
Total Co-Funding:	$772,363

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

NDE-4-13A Seam Weld Corrosion Detection with ILI Technologies

The project aims to provide users with the knowledge of current in-line inspection (ILI) capability to detect selective seam weld corrosion (SSWC) and differentiate it from coincidental corrosion that interacts with the long seam weld. A second targeted result is a step change in ILI capabilities for detecting, identifying, and characterizing SSWC. This project is an expansion of Pipeline Research Council International (PRCI) NDE 4–13—Selective Seam Weld Corrosion Detection with In-line Inspection Technologies, allowing the team to analyze more data, observe a larger sample, and ultimately understand how well ILI technology can differentiate SSWC from coincidental corrosion that interacts with the long seam weld. ILI technology will focus on the latest generation of circumferential magnetic flux leakage inspection tools with a higher density of sensors, as well as ultrasonic crack detection and electromagnetic acoustic transducer crack detection tools to detect any cracks that can develop at the tip of the "V" notch associated with SSWC. After kick-off in July 2023, project execution was rolled to NDE-4-13 by adding three more ILI vendors and four more ILI tools into the ILI pull testing and the subsequent data analytics. 4 of 7 ILI vendors have been provided feedback and one more vendor data has been received for analysis. The next step is to continue the study with seven ILI vendors. Upon successful completion, this work will inform decision-making around pipeline management at PG&E and other operators with benefit from the knowledge of shared operator and ILI provider experiences and the current ILI capability in SSWC detection and characterization.

Co-Funders: PRCI members

Start Date: 8/2/2023
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$275,412
Total PG&E Cost:	$10,000
Total Co-Funding:	$265,412

Benefits

NDE-4-17A SRP CM Pipeline Material Property Database Enhancement

A material property database has been developed by PRCI as part of the Data Hub project (NDE-4-17) in the Virtual Technology Development Center (VTDC). The PRCI Crack Management Strategic Research Priority (SRP) steering committee identified the need to enhance the existing PRCI material property database by performing a gap analysis for the existing database, adding more material property records, and developing guidelines for using the data extracted from the database. This PRCI project is to facilitate the collection of additional material property records for inclusion in the PRCI database. Anonymized data will mostly be shared by PRCI member companies. The project scope of work includes the following primary project tasks: Task 1—Identify gaps in the existing database; Task 2—Collect, prepare, and upload records in the database; Task 3—Develop guidelines for statistical data sampling from the database to use integrity management purposes. This project was kicked off in May 2022. In 2023, the datapoint compilation and revision/update of the current PRCI VTDC Material Property Database were completed. Task 3 was near completion as well. The next step is to upload the compiled data points to the current Database. Upon successful completion (expected Q2 2024), this work will enhance the existing database such that it will work as an industry resource to identify properties of materials that may be used as a representative for existing pipelines with material property records gaps in supporting Engineering Critical Assessment (ECA) processes and defect assessment processes. By accumulating a significant database of material properties, PG&E, and other pipeline operators would be able to comply with federal regulations and support pipeline integrity of systems that do not have available material test records.

Co-Funders: PRCI members

Start Date: 5/24/2022
End Date: 8/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$11,763
Total PG&E Cost:	$1,886
Total Co-Funding:	$9,877

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

Open Solutions for Historical Climate Data for California

PG&E has been working with Eagle Rock Analytics since 2020 to produce a data assimilation platform that serves as a central location for weather-related data of interest to natural gas stakeholders. Project work continues along the two main focuses: 1) assessing climate implications for reliability planning for fossil gas and 2) producing hourly quality-controlled versions of hourly weather data. During 2024, observational hourly weather data records for over 15,000 stations covering 43 years (1980 to 2022) have been cleaned, standardized, and placed in cloud-based storage. Finalization of automated quality assurance and control (QA/QC) processes is underway. This work builds on the project's earlier discussions with gas and other energy industry stakeholders regarding specific weather-data needs and concerns, as well as on development of quality assurance and control best practices and metadata standards for hourly weather data. The deliverables will support research efforts under California's Fifth Climate Change Assessment. The design and implementation of this work will ensure that historical climate data relevant to natural gas sector planning can be continuously updated and maintained at a low cost to ratepayers.

Co-Funders: CEC

Start Date: 9/27/2021
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,000,704
Total PG&E Cost:	$1
Total Co-Funding:	$1,000,703

Benefits

QLM Emissions Monitoring at Transmission M&R Stations

The purpose of this project was to utilize the QLM's Quantum Gas Lidar solution to quantify emissions at 10 intermittent bleed transmission M&R stations of various size and complexity and 1 compressor station, to aid in providing CPUC a strong case to update population-based emission factors. The data was analyzed, and a final report was completed in Q4 2024.

Co-Funders: N/A

Start Date: 8/1/2024
End Date: 12/31/2024
Status: Completed

2024 Funds Expended:	$61,843
Total Project Cost:	$18,700
Total PG&E Cost:	$22,400
Total Co-Funding:	-$3,700

Benefits

ROW-1-01 Using CP for Real-Time Detection of Mechanical Impact

This project was to assess the viability of the SPADE's cost-effective cathodic protection current monitoring system for real-time detection of mechanical impacts on steel pipelines under various scenarios and to determine the technology's operational conditions and limitations. There are 8 tasks conducted on 1) GRTgaz's test bed and transmission pipeline cathodic protection network in France; 2) PG&E's transmission pipeline cathodic protection network in USA: Task 1–Detection in real time of an electrical short between a pipe and its casing; Tasks 2–7—Detection in real time of an excavator's impact under various conditions (coating types, distance, soil resistivity, AC/DC Interference); Task 8—Detection in real time of illegal tapping. It entails welding a tap on the test pipe. Dig-ins to PG&E's underground assets are one of the leading risks to our assets. Many efforts are underway to identify and characterize dents and gouges on pipelines, including the interpretation of In-Line Inspection (ILI) data. Likewise, Damage Prevention strives to reduce dig-ins to PG&E infrastructure that result in ruptures. Damage Prevention sees dents as a potential leading indicator of future ruptures. The implementation of a technology that can identify pipeline strikes near real-time that result in dents will allow for a more rapid response to the site and preventative measures to be put in place to reduce the likelihood of future utility strikes. The project was kicked off in December 2022 and successfully completed all the planned testing in 2023 that confirming the technology's viability. The success of this project enabled PG&E to gain support and funding at Operations Technology Development (OTD) for a pilot-run project in 2024–2026. The final deployment of this technology will enable PG&E and other operators to detect and/or evaluate, in real-time, third-party damage causing minor damages like wrap damage and those causing ruptures and/or illegal tapping by monitoring CP current at rectifiers and identifying signal changes. PG&E and other operators will be able to identify the operational conditions and the limitations of the technology, supporting the decision as to the most effective deployments of the technology, leading to significant improvement in safety, reliability, and cost-saving.

Co-Funders: PRCI members

Start Date: 11/1/2022
End Date: 1/12/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$206,500
Total PG&E Cost:	$20,000
Total Co-Funding:	$186,500

Benefits

SIA-1-08 Guidance on the Assessment and Mitigation in Vintage Pipelines of Girth Welds

Many vintage girth welds would not meet the current workmanship flaw acceptance criteria meant for new constructions, such as those in API 1104. Without an alternative set of flaw evaluation criteria, many vintage girth welds would need to be mitigated (cutouts or reinforced) if they are evaluated against the current workmanship criteria. This Pipeline Research Council Internation (PRCI) project aims to develop a methodology that will allow operators to target potentially injurious girth welds and guarantee safety without having to mitigate welds suitable for service. The outcome of the work can be transferred to 1) American Society of Mechanical Engineer (ASME) B31.8(S), 2) American Petroleum Institute (API) Recommended Practice (RP) 1176 (management of cracks), 3) geohazards management programs, such as API RP 1187 and 4) pipeline repair manual. This project can lead to the reduction of greenhouse gas release by 1) reducing the unnecessary cutouts and 2) reducing the likelihood of leaks and ruptures. This project was kicked off in Q2 2024 and expected to be completed by Q2 2025. Upon successful completion of this work, PG&E and other operators will be able to assess the integrity of girth welds in vintage pipelines against the expected loads and determine if any mitigation measures are needed. The outcome will also help PG&E and other operators to choose appropriate mitigation measures.

Co-Funders: PRCI members

Start Date: 5/15/2024
End Date: 5/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$180,000
Total PG&E Cost:	$13,080
Total Co-Funding:	$166,920

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

T-786 Ph2 Classifying Methane Emissions at Regulator Stations

Methane emissions at transmission metering and regulating (M&R) stations are currently calculated using a population-based emission factor. This method prevents utilities from demonstrating the progress of methane mitigation efforts. A new measurement-based approach is necessary to demonstrate emission reduction. Phase 2 of this project aims to build on data collected in Phase 1. During Phase 1, NYSEARCH developed a ranking tool and framework to classify emissions from transmission M&R stations. Phase 2 will work to complete a test protocol allowing operators across the country to conduct emission measurements at their M&R stations. This data will be compared to values from the ranking tool developed in Phase 1. Using measured data and data from the tool will refine results and help operators determine which stations have a higher potential for fugitive emissions. After pilot visits are completed, the project team will analyze the data and issue a final test protocol. Field tests were conducted in SoCal gas territory in 2024. A final report is currently being generated.

Co-Funders: NYSEARCH members, Southern California Gas Company

Start Date: 6/3/2023
End Date: 3/31/2025
Status: Active

2024 Funds Expended: $9,095
Total Project Cost: $191,535
Total PG&E Cost: $28,375
Total Co-Funding: $163,160

Benefits

T-796 LDC Validation of Satelytics' Aerial System for Methane Detection and Emission Quantification

The objective of the project was to test Satelytics' aerial methane detection and emission quantification technology, including initial evaluation of its probability of detection (PoD) performance. Satelytics has adapted mid-infrared spectroscopy and satellite-captured imagery in near-Earth orbit, collecting methane detection emissions with associated GPS coordinates. Field tests using Satelytics' leak survey techniques, which included controlled methane releases, were conducted in 2024. The project team provided a final report summarizing the field trial findings. Unfortunately, the Satelytics system was unsuccessful compared to our current leak survey technologies concerning leak detection and quantification. Satelytics has offered an additional scan to PG&E at no cost since the system did not perform as expected. We are currently determining if and when that scan will happen.

Co-Funders: NYSEARCH members

Start Date: 8/10/2023
End Date: 9/30/2024
Status: Completed

2024 Funds Expended: $8,668
Total Project Cost: $649,497
Total PG&E Cost: $112,955
Total Co-Funding: $536,542

Benefits

T-797 LDC Validation of Bridger Photonics' Aerial System for Methane Detection and Emission Quantification

The objective of this project is to test Bridger Photonics' aerial methane detection and emission quantification technology including initial evaluation of its probability of detection (PoD) performance. Two field tests using Bridger Photonics leak survey techniques, which include controlled methane releases, were conducted in 2024, and a third will be done in 2025. Finally, a final report that will summarize the overall field test results and statistically calculate a perspective on PoD will be created. If successful, PG&E will have another leak detection technology in their inventory to potentially perform leak surveys and improve the overall operational confidence of the pipeline system.

Co-Funders: NYSEARCH members

Start Date: 7/26/2023
End Date: 3/31/2025
Status: Active

2024 Funds Expended: $18,844
Total Project Cost: $445,022
Total PG&E Cost: $80,912
Total Co-Funding: $364,110

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

U10 Sensor Evaluation for Leak Survey

The purpose of this project was to evaluate the U10 drone mounted sensor for leak survey to potentially provide PG&E leak survey team with another tool in the toolbox for performing leak survey specifically during emergency response, and for areas with large vegetation overgrowth. Because this sensor utilizes TDLAS technology, the sensor itself does not have to travel through the plume and can be used at a distance away enhancing safety for personnel. The project was completed following 2 field trails in the Pittsburg and Hercules area with promising results.

Co-Funders: N/A

Start Date: 7/1/2023
End Date: 12/1/2024
Status: Completed

2024 Funds Expended:	$9,165
Total Project Cost:	$1
Total PG&E Cost:	$1
Total Co-Funding:	$0

Benefits

US-4-04 Advancement of Through-Tubing Case Inspection for Underground Storage Wells

The project aims to advance sensor technology in through-tubing inspection tools, increasing their ability to detect, measure, and characterize metal loss features. The project team will work with Pipeline Research Council International to develop a Multi-String Well Integrity Platform that provides a circumferential measurement of corrosion and isolation of external casing strings. The deliverable will be an advanced technology sensor capable of acquiring data in a single run without pulling out the production string. In 2022, the engineering review, design, and assessment of through-tubing technology was completed. In 2023, the project team developed the preliminary reliability-based casing integrity assessment framework. Tool performance evaluation for several logging tests is ongoing. Before the test well setup, casing modules were assembled into individual casing joints by following a predetermined order of the metal-loss features for the third round of tests. By end of 2024, all the field logging testing will be completed. The field data analysis and further adjustments/refinement to the preliminary workflow based on the field trial results plus the final project report should be completed by Q2 2025. The development of this technological advancement will save Underground Gas Storage operators significant time and cost by providing the means to evaluate well integrity and effectively plan well intervention activities. Additionally, PG&E will utilize the results to manage well integrity as outlined in each field's Storage Risk Management Plan.

Co-Funders: PRCI members

Start Date: 9/30/2021
End Date: 9/30/2025
Status: Active

2024 Funds Expended:	$794
Total Project Cost:	$1,576,998
Total PG&E Cost:	$85,200
Total Co-Funding:	$1,491,798

Benefits

Project summaries: Decarbonization

1.16.H EnergyPlus Model for Gas Heating System Ph4

The project aimed to provide decision-makers with accurate and reliable modeling simulation tools for gas heating systems to enable fair comparison with competing technologies. An important goal for the gas industry is to allow the adoption of gas heating systems comparable with or better than high-efficiency electric alternatives. To achieve this, it is essential to provide reliable information regarding their potential benefits (e.g., cost and energy savings). Phase 4 of the project will focus on adding data on emerging gas heat pumps and hybrid gas-electric systems, which will build on the work accomplished in Phases 1–3, where the project team added data on advanced furnaces, tankless combined space/water heaters, and gas absorption heat pumps into the EnergyPlus model. This project will add performance data from advanced gas heating systems into EnergyPlus, thus increasing the visibility of gas options and allowing regulators and building developers. Those designing heating, ventilation, and air conditioning systems to model them and fully understand their operation and benefits.

Co-Funders: UTD members

Start Date: 6/1/2022
End Date: 4/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$16,667
Total Co-Funding:	$133,333

Benefits

1.17.B Ph4 Thermoelectric Generator for Self-Powered Water Heater

This project aimed to design, build, and test a complete alpha working prototype of a self-powered, high-efficiency tankless water heater capable of operating independently of the electric grid. Phase 4 focuses on integrating the system for deployment at a host site for prototype testing, with success measured by key performance indicators (KPIs), including a thermal-to-electric conversion for grid-independent operation, a coefficient of performance (COP) of 1.08, a drop-in design, ultra-low NOx emissions (<5 ppm), and an expression of interest from a potential commercialization partner. This phase built upon prior hardware testing and component development, refining the system to power a condensing tankless water heater. Phase 1 established feasibility through numerical and analytical models, Phase 2 validated the capability through technical analysis and benchtop testing, and Phase 3 optimized the design, demonstrating that a single Thermoelectric Generator-Heat Exchanger (TEG-HX) can generate up to 25We. The results of this phase will advance the commercial viability of self-powered, ultra-low-emission water heating technology.

Co-Funders: UTD members

Start Date: 7/1/2021
End Date: 5/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$240,000
Total PG&E Cost:	$10,000
Total Co-Funding:	$230,000

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.18.F Ph4 Mitigating Methane Emissions

This project investigated the impact of hydrogen-natural gas (H_2-NG) blends on fugitive methane emissions from end-use equipment while also refining the methodology for quantifying hydrogen slip. The study aimed to identify the root sources of emissions and assess potential mitigation strategies to support cleaner energy transitions. As part of the research, the project team tested a residential minimum-efficiency water heater and a pair of industrial burners with H_2-NG blends. The collected data is currently being analyzed and prepared for final reporting, which will provide insights into emissions behavior and inform strategies for minimizing hydrogen slip and fugitive methane emissions.

Co-Funders: UTD members

Start Date: 3/6/2023
End Date: 5/22/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$200,000
Total PG&E Cost:	$18,200
Total Co-Funding:	$181,800

Benefits

1.18.H Ph3 Economical High-Efficiency Residential Gas Absorption

The objective of the project is to build on the previous efforts to design, fabricate, and evaluate in laboratory settings a complete working "alpha" prototype unit that adds cost-effective cooling with low-global-warming-potential (low-GWP) refrigerant to the upcoming 40k British thermal units per hour version of the low-cost gas absorption heat pump (GAHP) product developed in UTD project 1.18.H with Stone Mountain Technologies Inc (SMTI). The GAHP uses an economical single-effect, ammonia/water absorption cycle. GTI Energy has estimated an annual fuel utilization efficiency of 140%. Still, the current unit only provides whole-house heating and domestic hot water. In this effort, the third phase, the project team will focus on a) the successful integration of said components and low-GWP module into an "alpha" prototype with heat recovery capability for combined space cooling and water heating, and b) the experimental evaluation of this prototype in steady state and simulated conditions, including a limited assessment of the viability of a "four-pipe" design for simultaneous space cooling and heat recovery for water heating. If successful, this effort will add a low-GWP vapor compression module to provide air-conditioning, reaching a seasonal energy efficiency rating (SEER) rating of 12.0 and heat recovery for water heating using SMTI's advanced hydronic air handler (AHU). Low-GWP refrigerants likely to be evaluated include R-32 but not NH3. SMTI is finalizing and launching a fully automated manufacturing process for 80k Anesi system production units and engaging in demonstration activities with multiple utilities in North America.

Co-Funders: UTD members

Start Date: 7/1/2023
End Date: 7/31/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$267,000
Total PG&E Cost:	$11,834
Total Co-Funding:	$255,166

Benefits

1.19.B Ph2 Gas Fired Warewasher

The project objective is to develop a gas-fired prototype of a conveyor-type warewasher (dishwasher). Door-type (low-volume) and conveyor-type (high-volume) warewashers represent a combined 43% of the market segment of warewashers. Most commercial warewashers are electric, and many use chemicals rather than high temperatures to disinfect, further increasing their environmental impact. Initial estimates indicate that a site will only use one-third of the source energy with a gas warewasher compared to alternative technologies. In this project, researchers and a manufacturing partner modified current electric warewashers, modeling different heat exchanger designs to determine the best-performing configurations that fit into the footprint of an existing electric warewasher. Various prototype heat exchanger(s) were fabricated and put into a prototype unit along with a burner and blower. The team tested a functional prototype for combustion efficiency, safety, and emission standards. Researchers modeled thirteen variations of heat exchanger designs and examined the combustion system in the lab-oratory with the prototype tank and heat exchanger. The project team used custom controls to tune everything, and the group achieved highly favorable results (under 10ppm NOx). Technicians assembled the burner, blower, and gas valve assembly, along with a new controller for the combustion system. The project group completed the initial testing of the combustion system with the prototype heat exchanger. The project team is in the process of identifying demonstration sites that have standard electric conveyor warewashers. The team will monitor their baseline performance and then install the new gas fired heat recovery warewashers and gas fired booster heaters to measure the energy and water savings of the new system.

Co-Funders: UTD members

Start Date: 7/1/2020
End Date: 3/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$175,000
Total PG&E Cost:	$13,988
Total Co-Funding:	$161,012

Benefits

1.19.B Ph3 Gas-fired Warewashers

The project objective is to develop and demonstrate a gas-fired prototype door-type warewasher (dishwasher). Door-type (low-volume) and conveyor-type (high-volume) warewashers represent a combined 43% of the market segment of warewashers. Most commercial warewashers are electric, and many use chemicals rather than high temperatures to disinfect, further increasing their environmental impact. Initial estimates indicate that a site will only use one-third of the source energy with a gas warewasher compared to alternative technologies. In this project, researchers and a manufacturing partner modified current electric warewashers, modeling different heat exchanger designs to determine the best-performing configurations that fit into the footprint of an existing electric warewasher. In 2022, the project team tested a control system for the door-type warewasher burner system that controls ignition for the burner, firing rate, and safety controls. Upon completion of the controller testing, the final prototype system will be sent to the manufacturing partner for further testing. The manufacturer will test one prototype in its facilities and one in the research laboratory to prove the machine's performance. Initial discussions regarding the field demonstration of the gas-fired door warewashers have begun. Research on the conveyor warewasher is currently focusing on heat-exchanger modeling and design.

Co-Funders: UTD members

Start Date: 11/1/2021
End Date: 1/31/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$145,000
Total PG&E Cost:	$3,625
Total Co-Funding:	$141,375

Benefits

1.20.B Boostheat Thermal Compression Gas Heat Pump

The objective of this project is to develop a North American thermal heat pump (THP) with a focus on 1) a high modulation ratio, 2) integration with forced-air distribution, and 3) adding cost-effective cooling. Project partner BOOSTHEAT has recently established an innovative and new business model in Europe. To successfully enter the North American market, however, this UTD project will address key product development needs. THPs have significant potential for 20% or greater improvement in energy savings and emissions reductions versus best-in class conventional sorption and vapor compression-type THPs. The project team completed laboratory preparations for testing the BH.20 using a Virtual Test Home (VTH) protocol. The test infrastructure is complete, and the remainder of the activity focuses on data acquisition and control setup. The test apparatus is undergoing shakedown to test a different heat pump before the arrival of BOOSTHEAT's unit. BOOSTHEAT experienced a production delay in 2020–2021 for various reasons. The company addressed key technical challenges and consolidated staff under a single roof. In early 2022, the company indicated that their new units' reliability and performance had improved. BOOSTHEAT is also re-developing the packaging and controls of the thermal compressor so that the BH.20 can provide both space heating and domestic hot water. BOOSTHEAT expects to make a unit available for testing and additional technical refinement (including using a VTH protocol) in the first quarter of 2023.

Co-Funders: UTD members, OEMs

Start Date: 7/1/2020
End Date: 12/31/2024
Status: Cancelled

2024 Funds Expended:	$0
Total Project Cost:	$225,000
Total PG&E Cost:	$17,666
Total Co-Funding:	$207,334

Benefits

1.20.G Combi System Integrating PV and Self Power

The project aimed to develop and demonstrate a hybrid residential combined heating, ventilation, air conditioning, and water heating (combi) system in the laboratory. The project used off-the-shelf appliances and novel controls to integrate gas and electric systems with micro-cogeneration, energy storage, and renewable energy systems. This approach reduced operating costs and greenhouse gas emissions by up to 50% and achieved a coefficient of performance of up to 1.5. This approach will improve energy resilience and help retain a high-efficiency role for natural gas and liquefied petroleum gas in the residential forced-air market. It also prepares the industry for nascent gas heat pump technology that will require solutions for system integration. In 2022, a residential nanogrid testbed achieved key performance markers. The team presented results from this project at the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 2022 Winter Conference and the World Gas Conference 2022 in Daegu, Korea, in May 2022. The team presented a paper in July at the Purdue 2022 Compressor Engineering, Refrigeration and Air Conditioning conference. The team will submit additional documents resulting from this research at the ASHRAE 2023 Winter Conference. In 2023, the project team formalized a project Test Plan with Enginuity; secured an Enginuity E-ONE micro-CHP (combined heat and power) system along with automated electric and thermal load banks in order to perform simulated use testing of E-ONE; and completed modeling of nanogrid systems to understand control options and quantify cost/emission reduction benefits. The team presented additional papers resulting from this research at the ASHRAE 2023 Winter Conference. The project team is optimizing the E-ONE 8kW Power System to operate as a standalone system. GTI Energy submitted an optimization plan for Enginuity to add hardware and control features to the E-ONE 8kW Power System and evaluate it to optimize power-led operation while operating at a high combined efficiency The team will install the E-ONE in a nanogrid testbed and begin simulated use lab evaluations.

Co-Funders: UTD members

Start Date: 7/1/2020
End Date: 2/28/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$550,000
Total PG&E Cost:	$16,502
Total Co-Funding:	$533,498

Benefits

1.20.H Ph1 Hydrogen-Blended Gas in Residential/Commercial Combustion Equipment

A number of researchers worldwide are investigating the impacts of hydrogen blending in fossil or renewable natural gas on end-use equipment safety and performance. While hydrogen as a fuel presents a number of challenges to existing combustion equipment, an emerging consensus suggests that low blends (e.g., <20% by volume) are suitable for existing equipment. Technology demonstrations are under way in Europe, where natural gas is predominantly used for heating. However, renewable energy production is high, primarily since imported natural gas prices are high, and environmental requirements are strict. Through these efforts, several products are undergoing development and demonstration, from domestic boilers to cooking ranges and their associated combustion components, that can safely and efficiently utilize up to 100% hydrogen fuels. Under Phase 1, this project seeks to build on these European efforts through extended technology transfer, while developing an R&D roadmap for hydrogen-blend-compatible equipment in North America, with an initial focus on >50% hydrogen blending by volume.

Co-Funders: UTD members, multiple OEM partners

Start Date: 7/1/2020
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$180,000**
Total PG&E Cost:	**$17,460**
Total Co-Funding:	**$162,540**

Benefits

1.20.H Ph2 High H_2 Fuel in ResCom Combustion Equipment

This project intended to support the potential deployment of up to 30% hydrogen blended gas in North American buildings. The team will assess the performance, emission, safety, and quality impacts of hydrogen mixing on widely used but low-load peripheral gas appliances such as gas lights, space heaters, outdoor fire pits, and indoor fireplaces. Specifically, the project team aims to determine the impacts and limits of hydrogen blending on these gas systems, assess qualitative results on aesthetic combustion equipment, and recommend changes for improved compatibility and performance. In 2022, test stands were built and modified for standardized testing of furnaces and water heaters. The team completed a preliminary literature review on relevant test and certification methods. The research team developed a comprehensive test plan, with testing expected to occur in the third or fourth quarter of 2022. As part of the R&D road mapping and outreach efforts under this project, the team prepared a summary paper for the World Gas Conference held in May 2022. Researchers demonstrated that methane emissions decrease with added hydrogen. The response to results was very positive, particularly with high interest from organizations in Latin America. There are several emerging options for distributed gas quality and hydrogen sensors. The project team is meeting with representatives from several sensor manufacturers. Preliminary results to date for this project were presented at a seminar at the American Society of Heating, Refrigerating, and Air-Conditioning Engineers' Winter Conference in February 2023. In 2023, the team also completed the commissioning of the test stand for Phases 2 and 3 and initiated tests with hydrogen blends in a hearth and gas furnaces in Q3 2023. In 2024, the project team tested a condensing 2 stage residential furnace and water heater test setup.

Co-Funders: UTD members

Start Date: 8/15/2020
End Date: 6/10/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$180,000**
Total PG&E Cost:	**$5,425**
Total Co-Funding:	**$174,575**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.20.H Ph3 Hydrogen-Blended Gas in ResCom Equipment

The project supported the potential deployment of up to 30% hydrogen-blended gas in North American buildings by assessing the performance, emissions, safety, and quality impacts on low-load peripheral gas appliances such as gas lights, space heaters, outdoor fire pits, and fireplaces. The team built and modified test stands for standardized furnace and water heater testing, conducted a literature review, and developed a comprehensive test plan, with testing beginning in late 2022. As part of outreach efforts, researchers presented findings at the 2022 World Gas Conference, demonstrating that methane emissions decreased with hydrogen blending, generating strong interest, particularly from Latin American organizations. The final report, issued in August 2024, highlighted key findings: hydrogen blends produced smaller, less bright flames, and users noticed differences, particularly at lower firing rates. A 30% hydrogen blend resulted in lower carbon dioxide and higher oxygen levels in flue gases, with carbon monoxide and NOx emissions showing minor variations. Radiant heat output was 20% lower than natural gas, with a detectable ~5°F difference. Operationally, the project observed no ignition failures or flashbacks up to 30% hydrogen, and fireplaces transitioned smoothly between fuels. The team also explored emerging hydrogen and gas quality sensors with manufacturers.

Co-Funders: UTD members

Start Date: 6/1/2022
End Date: 8/20/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$17,443
Total Co-Funding:	$132,557

Benefits

1.21.C Ph 1 CleanO2 CARBiNX Carbon Capture

This project aims to evaluate the performance of a CleanO2 CARBiN-X v 4.0 carbon capture device in the laboratory to validate claims of a carbon dioxide capture rate of 4 metric tons per year and cost savings of at least 30% for hot water heating. It will further identify areas for continued technical improvement. Implementing distributed carbon capture technology such as the CARBiN-X will help reduce greenhouse gas emissions in residential and light commercial and industrial spaces while allowing facilities operators to use natural gas in Zero Net Energy Buildings. The CARBiN-X v 4.0, CleanO2 team is working on more advanced prototypes to further disrupt the distributed carbon capture market. Depending on the progress in developing these prototypes, GTI Energy may perform preliminary regulatory and technical analyses to support the advancement of this technology. In 2022, The project team worked with CleanO2 to fully commission the new production version of the carbon capture unit in the improved experimental test stand for next-round tests. Researchers completed baseline and advanced testing and provide continued assistance to CleanO2 to refine the new system.

Co-Funders: UTD members

Start Date: 7/13/2021
End Date: 5/14/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$12,600
Total Co-Funding:	$137,400

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.21.C Ph 2 CleanO2 CarbinX Carbon Capture

This project helped develop and test CleanO2's next-gen commercial carbon capture unit (CarbinX v. 4) in a laboratory setting with a focus on condensing appliances, to demonstrate carbon capture efficiency ≥50% and payback period ≤5 years. This will enable condensing appliances, such as water heaters and boilers, to provide high-efficiency and low-carbon operation to residential and commercial building operators. With final experimentation for UTD 1.21.C Phase 1 having been completed, a baseline has now been established for the CarbinX v 3.3 technology. The lab testing and baseline performance for the current technology will be used to inform and guide the testing strategy for the next version of CleanO2's carbon capture technology. Based on discussions with CleanO2, the next available version will be a third-generation unit, rather than the version four, due to ongoing development of the next-generation technology. Multiple iterations of the v 3.x unit will be developed, tested, and piloted prior to release of the v 4.0. For this second phase project, the latest available unit will tested with a condensing boiler. Further discussions will be had with CleanO2 to plan the delivery and installation of the latest available unit.

Co-Funders: UTD members

Start Date: 7/13/2023
End Date: 5/14/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$220,000
Total PG&E Cost:	$13,000
Total Co-Funding:	$207,000

Benefits

1.21.E Gas Engine Heat Pump Modeling, Testing and Implementation

The project assessed the heating and cooling performance of a demonstration Gas Engine Heat Pump (GEHP) with an Air Handling Unit (AHU) Integration Kit, comparing it to the baseline federal minimum energy efficiency standard of an 80% Thermal Efficiency (TE) boiler and a 14 SEER air conditioner. Findings showed that GEHP heating efficiency decreased at colder ambient temperatures, while cooling efficiency remained consistent throughout the season. Part-load operation had the greatest impact on COPg, with short cycling reducing overall efficiency. Compared to the baseline systems, the GEHP demonstrated lower operating energy costs (excluding electric demand) and was more economically beneficial for facilities with high demand charges and heating loads. The project also found that the GEHP used less gas and produced fewer greenhouse gas emissions based on measured energy use and regional emission factors.

Co-Funders: UTD members

Start Date: 7/1/2021
End Date: 12/10/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$320,000
Total PG&E Cost:	$12,308
Total Co-Funding:	$307,692

Benefits

1.21.F Commercial Heat Pump Water Heater Field Performance Comparison

The project compares the performance of a commercial gas and electric heat pump water heater technology in 1–2 field locations and in GTI Energy's laboratory using the American Society of Heating, Refrigerating, and Air-Conditioning Engineers' standards to establish each technology's cost and energy-saving capability. The specific goals are: 1) to assess the performance of commercial gas and electric Heat Pump Water Heaters (HPWH) at GTI Energy and in the field and 2) to provide equitable comparative information between commercial heat pump technologies. Gas HPWH offers the gas industry a high-efficiency option for its Energy Efficiency gas incentive programs. At the same time, it allows customers to retain gas as an affordable, resilient, and reliable energy source. Gas HPWH can be deployed where the electric supply may be constrained, and supply and distribution upgrades may not be feasible within the end-user's timeframe. Propane-fired versions would provide an option for areas not served by gas infrastructure. Data evaluating the impact of deploying various HPWHs may also aid members in public dialogue regarding energy efficiency, options, and choices.

Co-Funders: UTD members

Start Date: 9/1/2023
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$136,000
Total PG&E Cost:	$5,232
Total Co-Funding:	$130,768

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.21.H Ph2 CFS Burner Technology Hydrogen Blending

The project aimed to determine the decarbonization potential of typical commercial food service (CFS) appliances when utilities blend up to 30% hydrogen with natural gas. Phase 2 focused on full appliance testing and cooking performance impacts and build on the testing of standalone burners and controls in Phase 1. GTI Energy, through its contacts at the North American Foodservice Equipment Manufacturers, worked with CFS manufacturers to identify and supply appliances for testing. Some key performance indicators included producing efficiency and emissions data for various stock CFS appliances. The team observed hydrogen blends operating at between 0–30%. The team created initial recommendations for relevant limits on hydrogen for a spectrum of stock CFS appliances. Finally, the project group assessed possible near-term modifications (e.g., controls or burner designs) to increase allowable hydrogen content. In 2021, a laboratory setup was designed and assembled to test CFS burners. The project team tested a fryer pilot burner as part of the shakedown of the test stand and data-acquisition system. During the shakedown, the team identified a need for a different capture hood and a more accurate gas flow meter. The project team addressed both issues, and testing resumed. In 2022, the team completed testing with the fryer pilot burner. The project team is completed testing of a tube burner in 2024.

Co-Funders: UTD members

Start Date: 6/30/2022
End Date: 9/26/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$160,000
Total PG&E Cost:	$17,778
Total Co-Funding:	$142,222

Benefits

1.21.I Ionic Liquid Heat Pump for Commercial Water Heating

The project designed and demonstrated an "alpha" working prototype of a low-cost, ultra-high-efficiency gas-fired commercial heat pump water heater (SOA-GHPWH) in a lab environment in partnership with the University of Florida and leading OEMs. The system utilized a mild ionic liquid to provide integrated latent cooling, targeting the efficiency of COPgas, HW ≥1.60 for hot water alone or COPtotal >1.80 when also providing indoor cooling and dehumidification. The prototype was performance-tested at commercial building loads with 100 gallons of storage and a nominal heating output of 145 kBtu/hr, using a simple plastic pump and primarily polymer construction materials. In 2021, the project team refined the product definition, considered codes and standards implications, and explored control specification options. Leveraging a parallel commercial HVAC effort, researchers also investigated deep dehumidification applications and a compressor-less HVAC version. In 2022, the team completed the fabrication of the desorber and advanced test rig assembly, conducting modeling, analysis, and component testing. In 2024, the project team continued preparations for prototype heating system testing, but completion was delayed at the University of Florida facility due to membrane absorber manufacturing issues. The project was completed in December 2024.

Co-Funders: UTD members

Start Date: 11/1/2021
End Date: 5/13/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$225,000
Total PG&E Cost:	$20,000
Total Co-Funding:	$205,000

Benefits

1.22.A Hydrogen Blending End Use Demo

This project intends to demonstrate blended hydrogen gas's safety, technical, and performance implications from an end-user perspective in a simulated neighborhood. The project aims to 1) measure the end-user performance and safety impacts of a wide array of fuel-fired equipment (e.g., HVAC, water heating, cooking), 2) quantify the efficacy of in-field retrofits and mitigation strategies for individual appliances, and 3) estimate the decarbonization potential of hydrogen blending through population modeling. In coordination with Southwest Gas, the project team seeks to leverage their utility training facility in Henderson, NV, as a hydrogen-blended equipment demonstration and outreach platform. The project will leverage the site's existing plans to install and operate an on-site electrolyzer to blend hydrogen at a variable rate into an islanded distribution network serving the training facility. The 15 homes within the simulated neighborhood will house the experimental equipment. In 2024, the project materials developed for planning, including the testing protocols and safety sensor/protocols were all drafted, adding to materials previously developed, including the demo plan, manual/automated test stand design/protocols, and preliminary safety analyses. The team has completed assembling the system controls/data collection items for pre-shipment check out. Southwest Gas will facilitate key modifications to the Triplex site that the project team will monitor and support, including the addition of A/C, enhanced venting, a patio area, laundry sink, and other items.

Co-Funders: UTD members

Start Date: 6/30/2022
End Date: 7/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$450,000
Total PG&E Cost:	$10,466
Total Co-Funding:	$439,534

Benefits

1.22.C Fuel-flexible Ultra-Low NOx Catalytic Burners for ResCom Appliances

The project will pave the way for the adoption of hydrogen-blended gas and address the need for deep nitrogen oxide (NOx) reduction in domestic burners by developing and demonstrating a catalytic combustion gas burner for residential and commercial applications that can accommodate up to 50% hydrogen while achieving lower NOx emissions than the current state of the art. Whereas standard burners combust fuel with oxygen at high temperatures, catalytic burners use catalysts to trigger a chemical reaction between the fuel and oxygen without creating a flame. The lower temperature helps minimize NOx production while providing a steady heat output to the load. A literature review report of available burners was developed, and updates are being finalized. The review builds on previous studies and other research underway on catalytic burners. The project team has contacted multiple burner manufacturers to secure burners to conduct testing. Three catalytic burners have already been secured to conduct testing on various fuel blends. The project team is setting up the testing space in an industrial laboratory in order to conduct individual burner testing. The final report is being drafted.

Co-Funders: UTD members

Start Date: 6/30/2022
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$34,200
Total Co-Funding:	$115,800

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.22.G Ph2 Safe Use of Hydrogen in Buildings

This project aims to enable the broad deployment of hydrogen-blended gas by proactively addressing consumer and regulatory concerns regarding its safe use in buildings. Phase 2 focuses on investigating fire safety barriers, assessing the increased risk of detonation, and developing mitigation strategies for hydrogen blends in buildings. The study primarily examines low-to-medium hydrogen blends with natural gas, up to 50% by volume. The project team kicked off Phase 2 by completing an analysis of leakage tests conducted in previous months. A conference paper summarizing the findings has been prepared and submitted for presentation at the ASHRAE Winter 2025 Conference.

Co-Funders: UTD members

Start Date: 7/1/2024
End Date: 2/28/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$225,000
Total PG&E Cost:	$43,270
Total Co-Funding:	$181,730

Benefits

1.22.G Safe Use of Hydrogen in Buildings

The project aimed to enable the broad deployment of hydrogen-blended gas by proactively addressing consumer and regulatory concerns about its safe use in buildings. This project characterized the propensity of hydrogen in blends with natural gas to preferentially leak from existing building gas distribution systems and appliance gas handling subsystems. The project also addressed barriers to the safe use of hydrogen blends greater than 30% in residential and commercial appliances. Some key performance indicators are 1) quantifying leakage of hydrogen-blended gas compared to natural gas from standard fittings, 2) identifying design requirements for high-hydrogen blend (i.e., 40–100%) operation, and 3) publicly disseminating findings and recommendations through peer-reviewed publications and webinars. In 2022, GTI Energy kicked off the project with a literature review into prior research on preferential hydrogen leakage from low-pressure gas distribution systems and fundamentals of detonation wave formation for mixtures of methane and hydrogen. GTI Energy is also working on installing and configuring Converge computational fluid dynamics (CFD) software, which will be used to analyze detonation wave formation. The project achieved several key progress indicators, including quantifying hydrogen-blended gas leakage, confirming leak-free systems with 30% H_2, and influencing future appliance and building codes.

Co-Funders: UTD members

Start Date: 7/31/2022
End Date: 12/12/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$8,824
Total Co-Funding:	$141,176

Benefits

1.22.H Ph2 Hybrid Fuel-Fired and Electric-Driven Rescom HVAC Systems

This project aims to develop and characterize the simultaneous operation of a hybrid (dual fuel) gas furnace/electric heat pump in a laboratory environment to demonstrate its performance, and then develop installation and operational guidelines for its efficient and cost-effective use in various climate zones. The prototype will be developed in collaboration with Carrier based on their gas furnace and high-efficiency heat pump. Current off-the-shelf hybrid (dual-fuel) systems can only operate either the gas furnace or the electric heat pump at any given time, can be sized for peak load, and limit the annual utilization of equipment. Proposed simultaneous hybrid (dual-fuel) systems could Minimize operating costs and GHG emissions while maximizing the utilization of the equipment.

Co-Funders: Carrier

Start Date: 10/1/2024
End Date: 10/30/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$220,000
Total PG&E Cost:	$20,000
Total Co-Funding:	$200,000

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.22.P Ph2 Emerging Distributed Methane Pyrolysis Technologies

The project surveyed distributed methane pyrolysis technologies, conducting a techno-economic assessment across various applications, including the conversion process, hydrogen end uses, carbon output handling, and potential contaminant or purity considerations. The team performed in-depth technology reviews and interviewed five or more companies using distributed methane pyrolysis solutions, such as Modern Hydrogen, gathering insights from literature and data collection to complete a comprehensive techno-economic analysis. The study evaluated hydrogen end-use scenarios (e.g., boilers for space heating) and carbon output scenarios (e.g., disposal). Given the goal of completing this effort within the cycle and before Phase 2, the team also developed a preliminary system modeling plan to integrate with end-user demand modeling, identifying methane pyrolysis solutions categorized as good, better, or best. This study focused on methane pyrolysis, or "turquoise" hydrogen, an emerging hydrogen production pathway that enables hydrogen generation closer to the point of use, potentially reducing costs compared to other production methods.

Co-Funders: UTD members

Start Date: 9/1/2023
End Date: 6/18/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$170,000
Total PG&E Cost:	$23,182
Total Co-Funding:	$146,818

Benefits

1.23.E Combustion Technology for Emerging Low Carbon Manufactured Gases

The objective of the project is to conduct an experimental, technical, and safety evaluation of equipment that is designed or being operated with manufactured gases in non-North American markets, with a focus on water heating and cooking applications. Evaluations will include performance and reliability tests and identify fundamental principles to apply to the types of natural gas-certified equipment typically sold in North America. The project team will also conduct a safety and technical review of emerging low-carbon manufactured gases used in water heating, cooking, space heating, etc. In this investigation, utility members will be equipped with design specifications and performance data for appliances designed for markets already using hydrogen-rich manufactured gases. Utilities will be able to close the knowledge and design gap for the industry's shift from current natural gas (NG) to NG/hydrogen blends. Investigating other potential fuels outside NG/hydrogen blends will give utilities options for more carbon-neutral fuels. Other performance issues outside efficiency and emissions may not cover the specific needs of individual communities or industries. The project can prepare utilities with additional fuel information for these niche markets within the North American market.

Co-Funders: UTD members

Start Date: 7/1/2023
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$225,000
Total PG&E Cost:	$14,940
Total Co-Funding:	$210,060

Benefits

1.23.G Accelerated Life Testing of ResCom Equipment Components with Hydrogen-Blended Gases

The project aims to assess the compatibility of commonly used non-burner components in residential/commercial (Res/Com) combustion appliances and equipment when subjected to hydrogen-blended gas. This assessment will help gas equipment and appliance manufacturers, gas utilities, standards-setting organizations, and other entities better understand the potential challenges of using hydrogen in natural gas distribution networks. Project deliverables include 1) a report listing component compatibility or degradation when exposed to hydrogen and 2) a recommendation of mitigation strategies for any problems identified. No fuel quality standards exist for hydrogen appliances, nor have existing appliances been tested with hydrogen. As a result, multiple projects at GTI Energy and other organizations are looking at the long-term durability of appliances and burners with hydrogen and investigating the compatibility of components upstream of the burner. In 2024, The team completed a literature review of prior studies on material compatibility testing, pointing to remaining knowledge gaps and a need for confirmation of other results. The team has also begun developing a test plan, which will use an enclosure to expose components to 100% H_2 for a fixed duration, followed by operational testing.

Co-Funders: UTD members

Start Date: 7/1/2023
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$150,000
Total PG&E Cost:	$16,500
Total Co-Funding:	$133,500

Benefits

1.23.I Inherently Safe ResCom Combustion Systems for Hydrogen-Blended Gases

The objective of the project is to ensure the safe, reliable, and efficient operation of customer gas appliances with hydrogen-blended gas (5-50% hydrogen by volume) by 1) developing ands demonstrating inherently safe combustion systems for common gas appliances (furnaces, water heaters, ranges, etc.) and 2) identifying inexpensive options to retrofit typical existing appliances (e.g., deployed in less than one hour at a cost of <$100). This will help gas utilities demonstrate hydrogen blending levels well above 5% by volume and broadly deploy blended gas in their networks. Hydrogen blending at a level of 5% by volume using green hydrogen will only result in an emission reduction of <2%. To achieve deep decarbonization, much higher levels of green hydrogen are needed (e.g., at 30% hydrogen, emission reduction is 13%). While early pilot projects with low blends help develop the necessary blending infrastructure, if gas utilities and their customers are to reach their decarbonization goals, higher blend levels will need to be deployed sooner rather than later. Higher blends of hydrogen are likely tolerable by most conventional gas appliances. However, in cases where 10–40% hydrogen creates combustion instabilities, these can be a nuisance or catastrophic. Accidents will also be complicated to predict. The solutions this project seeks to explore could be easily implemented by appliance installers or technicians completing home inspections ahead of any pilots. A potential solution could be as simple as a gas orifice replacement to ensure that all appliances in customer homes will be safe with higher blends of hydrogen. The project kicked-off in Q3 2023 and began an initial literature and prior art review regarding flashback-resistant burner and air-fuel mixer designs. The team engaged with a simulation consulting firm to perform a portion of the analysis. In 2024, GTI kicked off the subcontract to perform computational fluid dynamic simulations. The team is also progressing in literature and background review.

Co-Funders: UTD members

Start Date: 7/1/2023
End Date: 4/22/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$175,000
Total PG&E Cost:	$9,579
Total Co-Funding:	$165,421

Benefits

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1.23.J Hydrogen Flame Visibility and Colorants

The project aimed to evaluate and identify colorants for hydrogen-enriched gaseous fuel at various conditions to 1) establish a matrix of hydrogen/methane mixtures to test visibility from 0% to 100% hydrogen and 2) enhance the safety of open flame operation of hydrogen-enriched natural gas at four common lighting conditions with appropriate and safe gas colorants. Gaseous colorants can allow the hydrogen/natural gas fuel to mimic natural gas flames. This will help gas utilities address the safety concerns of gas end users regarding the appearance of hydrogen-enriched flames. Blending renewable hydrogen into natural gas infrastructure is a practical solution for decreasing carbon emissions. However, one major challenge is to ensure safe operation and address end users' safety concerns regarding the performance deviation of hydrogen/natural gas mixtures from traditional natural gas flames. In 2023, the project kicked off: the project Team identified a burner and created a CAD document to replicate the burner at GTI Energy. In 2024, the experiment setup was finished together with the electrolyzer generating hydrogen onsite. Flame color quantification for hydrogen and methane mixtures was finished, and flame colorants were identified.

Co-Funders: UTD members

Start Date: 7/1/2023
End Date: 6/20/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$150,000**
Total PG&E Cost:	**$11,833**
Total Co-Funding:	**$138,167**

Benefits

1.24.E Tour Engine ENABLE Microgrid mCHP System

This project aims to evaluate and support the development of the Tour ENABLE system, a hybrid micro-combined heat and power (mCHP) system integrating a 5 kW engine, 15 kW generator-battery system, and advanced heat recovery technologies. The system is designed to support hydrogen (H_2) blending from 30% up to 75% while meeting California Air Resources Board (CARB) Distributed Generation (DG) compliance requirements. Key objectives include techno-economic analysis (TEA) and greenhouse gas (GHG) emissions assessments and optimizing design, heat recovery, and operational strategies for mCHP-based nanogrid applications. Additionally, the project supports the CEC HyBLOX initiative. The project team has successfully tested the Tour Engine with H_2 blends up to 50% and is preparing a high-H_2 test safety protocol and a CARB DG certification test plan. The project team has also completed the initial framework for a detailed TEA and life-cycle assessment (LCA) analysis.

Co-Funders: UTD members

Start Date: 7/1/2024
End Date: 1/31/2026
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$60,000**
Total PG&E Cost:	**$1,500**
Total Co-Funding:	**$58,500**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

1.24.H Safe 100% Hydrogen Appliances for Homes

The project team of GTI Energy working with Enertek Int'l and multiple product manufacturers will seek to demonstrate the feasibility of a range of 100% H_2-compatible equipment for UTD, disseminating the results of product development and laboratory testing to multiple stakeholders. These include North American heating equipment and appliance manufacturers, relevant safety codes and standards authorities, and regulatory/policy stakeholders. GTI Energy will leverage its on-going stakeholder engagement with the following organizations, to maximize the impact of this product development effort. While decarbonization is the primary benefit of utilizing hydrogen-based fuels, this project is primarily focused on end-user safety, which includes the development and validation of inherently safe product designs, product enhancements for operator safety and end user feedback, and the best practices for installation and operation. Examples of each includes burner designs for flame flashback mitigation, non-flame visual indicators of the cooktop burners, and specific guidance for the ventilation of 100% H_2-compatible appliances. The intent of this project is to focus on aspects of end-user safety in the design/conversion of these novel appliances, while quantifying issues of product performance, efficiency, end use comfort, and emissions (GHG, NOx, CO).

Co-Funders: UTD members

Start Date: 7/1/2024
End Date: 7/1/2026
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$300,000**
Total PG&E Cost:	**$31,264**
Total Co-Funding:	**$268,736**

Benefits

1.24.I Modern Interchangeability Indices for Hydrogen-Enriched Natural Gas

This project addresses a key technical barrier in assessing the interchangeability of gaseous fuels and accelerating the development and integration of hydrogen-compatible burner designs and hydrogen blending into natural gas pipelines. The study evaluates existing natural gas quality standards (tariffs) from UTD members, examining gas quality characteristics such as heating value, Wobbe index, and flame indices. It identifies limiting factors for hydrogen blending within current tariffs and quantifies thresholds to enable hydrogen integration. The project includes theoretical analysis and calculations using historical and existing flame indices (AGA, Weaver, Knoy, etc.) to determine fuel interchangeability thresholds, along with experimental verification of flame indices' effectiveness in predicting flame behaviors. In 2024, the project team collected vintage documents from fuel interchangeability research dating back to the 1920s–1970s, conducted summary and analysis of existing flame indices, and established conversations with the American Gas Association and the Canadian Standards Association during the AGA H_2 Blending Workshop.

Co-Funders: UTD members

Start Date: 7/1/2024
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$150,000**
Total PG&E Cost:	**$32,294**
Total Co-Funding:	**$117,706**

Benefits

1.24.Q CarbonQuest End-Use Carbon Capture

This project focuses on optimizing CarbonQuest's carbon capture technology at the process level to enhance performance and advance the technology from Stage 5—Product Development to Stage 6—Deployment. The study evaluates the base skid configuration using simulation tools to assess potential carbon capture rates for boilers rated at ≥3,000 MBH and reciprocating engines with a baseload electric capacity of ≥200 kW. A model will be developed to implement the optimized skid configuration, providing estimated GHG reduction improvements compared to CarbonQuest's current field demonstrations. The project also examines the effectiveness of CarbonQuest's technology in flue gas streams of commercial and industrial boilers and reciprocating internal combustion engines, expanding potential applications beyond conventional buildings. Optimization will be achieved through process simulation, process modeling, and equipment skid design/configuration. A modeling study will be conducted to demonstrate a ≥50% reduction in GHG emissions from a gas-fired application while achieving a 3–7 year payback period, reinforcing the commercial viability of the technology.

Co-Funders: UTD members

Start Date: 4/15/2024
End Date: 7/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$160,000
Total PG&E Cost:	$21,818
Total Co-Funding:	$138,182

Benefits

1.24.R Impact of Trace Constituents in Renewable Natural Gas on Appliances

This project aims to advance the use of RNG by addressing end-user concerns about the impact of trace constituents on end-use appliances, when the percentage of RNG becomes a large portion of the total delivered gas. This project will perform accelerated life testing of water heaters with trace constituents of concern (e.g., hydrogen sulfide and halogenated hydrocarbons) in order to inform and improve gas utility interconnection guideline requirements as they pertain to trace constituent levels. In 2024, the project was kicked-off and test planning is underway.

Co-Funders: UTD members

Start Date: 10/1/2024
End Date: 10/1/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$250,000
Total PG&E Cost:	$76,667
Total Co-Funding:	$173,333

Benefits

2.14.O Ph3 Gas Quality Sensor Validation H_2 Sensor

This project aimed to broaden the Gas Quality Sensor (GQS) capability to measure gas composition, heating value, Wobbe number, and methane number for natural gases blended with hydrogen. Indicators that the team sees suggest that GQS accuracy will improve when they add a hydrogen detector. The team will add a hydrogen detector to the previously developed GQS and conduct calibration tests in the project's third phase. Phase three will provide data allowing the extension of the GQS capabilities beyond natural gases to hydrocarbon fuel gas mixtures containing hydrogen. The team will give the generated data to the licensee CMR Group, and combining it with their data, will help to accelerate GQS deployment with hydrogen detection capability. The team will conduct testing in the GTI Energy Industrial Combustion Laboratory's Optical lab space. The lab has the needed blending station, mixing system, computer, and data acquisition system. When CMR is ready to ship the GQS unit for testing, GTI Energy engineers will acquire needed calibration gases and set up instrumentation and data collection computers. This work will take a small amount of the team's time and needs to be conducted just before testing the GQS unit.

Co-Funders: UTD members, CMR Group

Start Date: 7/1/2021
End Date: 7/15/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$75,000
Total PG&E Cost:	$5,000
Total Co-Funding:	$70,000

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

2.16.A Ph3 Next Generation Infrared Burner: Field Test

The project aimed to design, build, and field-test a prototype of a next-generation, high-response, higher-efficiency infrared burner. Key performance indicators and goals to measure and demonstrate the success of Phase 3 will be to show: 1) improved efficiency of at least 4% versus existing gas-fired units, 2) improved start-up times of <3 seconds through advanced materials, and 3) reliable burner operation at the host site for at least 100-200 hours. Burner manufacturer Solaronics has been offering the new technology to its customers. Still, only about 20% of Solaronics' customers have shown potential interest in the new metal foam burners since the technology is not entirely demonstrated and field-proven. Phase 3 addressed this market penetration hurdle by putting a near-commercial prototype at a customer-host site for testing and demonstration. In doing so, Phase 3 advanced the introduction of another new high-performance commercial product that efficiently uses natural gas and, with its high-performance response, can compete and be successful in a product category that is dominated by electric units, which on a source-energy basis, may consume three times as much energy as the gas-fired ones.

Co-Funders: UTD members

Start Date: 6/1/2020
End Date: 7/19/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$300,000
Total PG&E Cost:	$14,600
Total Co-Funding:	$285,400

Benefits

2.16.A Ph4 Next Generation Infrared Burner: Hydrogen Focus

This project aims to test and optimize the performance of the new gas-fired IR burner that UTD is developing under previous project efforts (2.16.A) in partnership with Solaronics, Inc.—a leading gas-fired IR heater OEM, and a top metal foam material OEM. The goal is to operate on high hydrogen blended natural gas, perform tests on the burner with up to 100% hydrogen, and optimize the design to achieve fast start-up, uniform temperature profile, and ultra-low emissions (i.e., < 5 ppm NOx, < 30 ppm CO). Some key performance indicators include demonstrating stable operation with up to 100% hydrogen, providing comparative analysis in terms of temperature, heat flux, stability, emissions, and turndown capability, and achieving fast start-up, uniform temperature profile, and ultra-low emissions. In 2022, the team performed heat-flux measurements for different conditions and compared them with the performance of traditional IR burners. Researchers reviewed the data from the host site, and these looked promising. The team expects more discussions with the manufacturing partner and the host site, and they will gather additional data. In 2024, the team setup the test rig for hydrogen testing. Flow meters, instrumentation and controls are being assembled for the testing and data collection.

Co-Funders: UTD members

Start Date: 6/30/2022
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$180,000
Total PG&E Cost:	$20,000
Total Co-Funding:	$160,000

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

2.20.A Ph2 Low Emission Efficient Burner for Ovens and Dryers Hydrogen Focus

This project advances a novel, low-emission burner designed to operate efficiently under crossflow or end-flow process air and low-turndown conditions while achieving 9 ppm NOx emissions and <50 ppm CO emissions—a significant innovation in the industry. The burner assembly is manufactured using 3D printing, enabling a single-step fabrication process that reduces labor and tooling costs and eliminates the need for brazing multiple nozzles. This innovative approach not only reduces emissions and equipment costs but also expands ratepayer choices by introducing another product to the market. The project integrates novel burner technology previously developed with UTD support into a 3 MMBtu/hr burner assembly system designed for process air heating applications. Performance validation will occur first in the laboratory and then at an end-user's field host site, with a cross-flow air-duct assembly providing heated air for simulated process-heating applications. The burner's temperature will be controlled by firing rate, and researchers will fabricate and test the system for air-heating applications such as ovens and dryers using up to 50% hydrogen blends with natural gas. The project team is partnering with a manufacturer of process heaters to accelerate the commercialization of this advanced burner technology.

Co-Funders: UTD members

Start Date: 7/1/2022
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$180,000**
Total PG&E Cost:	**$20,000**
Total Co-Funding:	**$160,000**

Benefits

2.20.A Ph3 Low Emission Efficient Burner for Ovens and Dryers

Design, build and factory-test an innovative 3D printed, UTD-patented burner at 3 MMBtu/h capacity for air heating applications (such as ovens and dryers) with natural gas (NG). Phase 3 will focus on installing a commercial prototype in the factory of Preheat, Inc. (the anticipated commercializing entity) that was developed in Phase 1 in partnership with Preheat. The technology has the potential to reduce NOx emissions by >80%, CO emissions down from 300 ppm to 50 ppm, reduce blower requirements by 30%, and increase efficiency by 4%. In 2024, the team evaluated current data with OEM's to move the technology forward. Discussions with host site for testing in progress.

Co-Funders: UTD members, Preheat Inc., Oak Ridge National Laboratories

Start Date: 6/1/2023
End Date: 7/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$100,000**
Total PG&E Cost:	**$5,000**
Total Co-Funding:	**$95,000**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

2.20.F Next Generation NGV Driver Information System

This project aimed to develop and demonstrate a next-generation natural gas vehicle (NGV) driver information system that provides an accurate miles-to-empty estimate for the vehicle. This hurdle is particularly challenging in gaseous-fueled cars because the gas experiences a wide range of temperature fluctuations as the pressure changes during fueling and engine operation. UTD's co-funding will leverage the objectives of a separate prime contract award to GTI Energy by the U.S. Department of Energy (DOE) that provides $1,000,000 in federal funds plus $1,000,000 of in-kind partner support. GTI Energy will model the thermodynamics of the vehicle tank(s), the key technical hurdle for this project. Argonne National Lab will adapt a previously developed NGV fleet navigation application to utilize the miles-to-empty data to optimize fleet efficiency. After the DOE project, the team will engage potential commercial partners for licensing opportunities. In 2022, the project team successfully installed and demonstrated the first Driver Information System on a truck. Once the display is validated, the team will install the system in 11 more vehicles. In 2023, fuel gauge displays were installed on eight concrete delivery trucks. The fuel gauges use data from the sensors installed on the vehicle and engine data (distance traveled and fuel mass flow rate). Distance-to-empty is predicted using readings from these sensors combined with operating history data. This distance-to-empty calculation has been validated to be accurate within the upper and lower bounds displayed. A custom end plug incorporating an in-cylinder temperature sensor was also designed. This will enable the temperature data to be uploaded through the Controller Area Network system without requiring an expensive data acquisition unit. The team has also started discussing deployment in a commercial fleet.

Co-Funders: UTD members

Start Date: 7/1/2020
End Date: 9/10/2024
Status: Completed

2024 Funds Expended:	**$0**
Total Project Cost:	**$250,000**
Total PG&E Cost:	**$100,000**
Total Co-Funding:	**$150,000**

Benefits

2.20.G Ph2 Smart CNG Station Demo

The project aims to develop a smart compressed natural gas (CNG) fueling station system to enable "full fills" of CNG vehicles and demonstrate the system at five field locations. Heavy-duty CNG trucks often experience "under-filling" to 20–25%, as frequently cited by industry experts. The smart station will communicate live gas properties between the vehicle and the pump so that the gas mass in the tank can be accurately predicted. The outcome of Phase 2 is a commercial prototype of the smart dispenser hardware and the results of demonstrating this technology on CNG trucks. Researchers deployed 18 HEM data-acquisition systems (HEM DAS) onboard a local fleet of concrete mixers. This allows the project team to collect fueling and fuel consumption data onboard each vehicle to better understand how baseline dispensers operate and how much they truly underfill vehicles. The system transmits data about the fuel system to the cloud, where investigators download and evaluate fills and driver-filling practices. During 2023, the team continued actively testing the smart controller and algorithm using a commercial CNG dispenser and two target cylinders connected to HEM DAS. This continued into 2024. The technology solution will provide consistent full-fills to CNG heavy-duty trucks. This should result in more minor fuel tank requirements, longer time between refueling, and more confidence in the trucks' range. CNG trucking can be a pathway for renewable natural gas to replace diesel fuel eventually, and this technology could reduce the capital cost differential between CNG and diesel trucks. In 2024, GTI has successfully bench-tested hardware that will enable the team to override the dispenser shutoff and allow the smart station controller to achieve a fuller fill. The project team installed the overriding hardware in the ANGI dispenser. The team demonstrated that the dispenser valve can be externally controlled without harming the dispenser and is now debugging the control code to better control the override.

Co-Funders: DOE, UTD members

Start Date: 7/1/2020
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$2,000,000**
Total PG&E Cost:	**$32,053**
Total Co-Funding:	**$1,967,947**

Benefits

2.20.G Smart CNG Station—Field Demonstration

The project sought to develop a smart compressed natural gas (CNG) fueling station to increase usable, "onboard" CNG storage capacity by 10–25% and demonstrate it at five field locations. This improved fueling system will provide consistent "full-fills," resulting in lower capital costs for fuel storage on natural gas vehicles and reduced operating costs for filling. The Smart CNG station will communicate live gas properties between the vehicle and the pump so that the gas mass in the tank can be accurately predicted. This will result in the full capacity of the tank being utilized instead of a pressure limit artificially limiting the molecules of natural gas allowed into the tank. Part of PG&E's natural gas strategy is developing new potential end-uses for natural gas. One of the most promising is heavy-duty transportation, including trucking, as replacing gaseous/liquid fuels with battery electric is difficult, given the typical duty cycles. Anything that has the potential to significantly improve the customer's experience with heavy-duty natural gas trucks is critical to expanding it as a future end-use.

Co-Funders: DOE, UTD members

Start Date: 7/1/2020
End Date: 3/14/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$4,320,000
Total PG&E Cost:	$120,000
Total Co-Funding:	$4,200,000

Benefits

2.21.A Ph 2 High Hydrogen Burner for Commercial and Industrial Applications

The proposed project will design, develop and test stable and robust operation with up to 100% H_2 with room temperature air, with recuperative design up to 400°F/204°C air and regenerative design of up to 1000°F/540°C inlet air operation up to 2 MMBtu/h firing. The proposed effort will advance the technology from Stage 4—Technology Development to Stage 6—Deployment. Design, fabricate, and test an advanced fuel-flexible 3D-printed hydrogen/renewable natural gas (H_2/RNG) up to 2 MMBH burner in a commercial/industrial scale furnace at GTI Energy, including a new high air inlet temperature (recuperative and regenerative) configuration in order to achieve higher temperature operation, higher efficiencies when operating solely on NG in certain applications, and higher H_2 blending percentages than was achieved in Phase 1. Phase 2 will further advance this UTD-patented technology towards commercialization and help expand future potential applications to markets such as food and beverage, air heating and drying, applications in the automotive and metals finishing industry, paper, pulp and forestry applications and other energy intensive industries.

Co-Funders: UTD members, Bloom Engineering, CSI, Gopher Resources

Start Date: 7/2/2024
End Date: 7/2/2027
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$300,000
Total PG&E Cost:	$60,000
Total Co-Funding:	$240,000

Benefits

2.21.B Ph2 Energy Recovery from Brewing-Distilling Operations

This project is developing and demonstrating a Waste Heat Effective Transfer (WHET) energy recovery technology in brewing/distilling operations to validate the technology as a robust and reliable operation where waste heat is available and water heating is needed. The innovative WHET technology combines commercially available technologies into a simple, reliable, compact, and inexpensive system to economically recover and reuse low-level waste heat. Previous waste-heat-recovery systems have been large, complex, and often too expensive to be deployed because payback times from natural gas savings were too long. WHET systems can operate efficiently and economically at virtually any scale in any industrial setting where waste heat is available and there is a need for hot water or heated water entering a boiler. The WHET process is designed to be inexpensive, easy to install, and nearly invisible to the plant operator. Simple payback periods are expected to be under five years.

Co-Funders: CEC, UTD members

Start Date: 8/1/2023
End Date: 7/14/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,470,000
Total PG&E Cost:	$70,000
Total Co-Funding:	$1,400,000

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

2.21.B Energy Recovery from Brewing/Distilling: Field Demo

The objective of this project is to validate the WHET waste heat recovery technology at two microbreweries providing robust and reliable operation where waste heat is available and water heating is needed. The WHET process will economically recover heat from brew kettles and use that heat for water heating. This approach will provide sufficient operational flexibility to match variations in facility operating load. The project will also demonstrate the cost-benefits of the Waste Heat Effective Transfer (WHET) technology by achieving a payback period of less than five years. A technology transfer plan will be prepared. This project is leveraging $1.4 million in prime CEC funding and supports the CEC project objectives. There are over 1000 breweries and 100 distilleries in California that can benefit from the WHET system and save up to 25% of their energy costs. Additionally, there is a potential to deploy the technology at the 30,000 commercial laundry facilities in the country which consumes roughly $800 million in electricity per year. 20% energy savings would lower energy demand by $160 million per year. In 2024, the project team has completed collecting data at the first demonstration system installation at Tower Brewing. Installation and shakedown is complete at Alaro Brewing, the second site. Data collection was begun at Alaro with commissioning of the demonstration system. Demonstration testing will continue next quarter at Alaro. The Field Test Agreement is now in place with Alaro Brewing.

Co-Funders: CEC, UTD members

Start Date: 11/1/2021
End Date: 6/17/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,670,000
Total PG&E Cost:	$144,712
Total Co-Funding:	$1,525,288

Benefits

2.21.C Ph2 Zero Emission Processes with Carbon Recovery

The project's objective is to complete synthetic air combustion process layouts, balances, and cost estimates in preparation for submitting demonstration proposals to Sponsors including DOE and CEC. Recent testing results will be used to validate layouts, mass and energy balances, and costs of the synthetic air combustion (SAC) process with CO_2 capture.

Key performance indicators and metrics to measure project success will be:

- Natural gas savings of 8–15%
- CO_2 reduction of up to 15%
- Elimination of NOx
- O_2 cost lower than cryogenic route—a prominent path to explore is the use of waste heat and perovskites to collect O_2 from air (technology to be explored with researchers from North Carolina State University)
- Applicability to wide range of industrial furnaces and boilers

This project will build upon the recent SAC work completed under 1) SMP project 22761, which focused on limited ambient temperature SAC combustion with oxygen and CO_2, and 2) Phase 1 of UTD project 2.21.C, which tested SAC operation with synthetic air composed of oxygen, CO_2, and H_2O. The SAC technology was recently proposed to DOE; The work in the project is important because there is strong interest among multiple sponsors to reduce or eliminate industrial carbon emissions. Potential Sponsors including CEC and the DOE (Fossil Energy, Advanced Manufacturing Office (AMO), and the Center for Sustainable Fuels and Chemicals). These groups and others have issued recent solicitations or are expected to issue solicitations in the next one to two years. The laboratory results, data and progress to be generated in this UTD project will advance the technology and provide scientific data, SAC layouts, preliminary mass and energy balances, and estimated costs to support future consideration by DOE and CEC for future, larger prime contract awards to further develop and deploy the SAC technology.

Co-Funders: DOE, UTD members

Start Date: 8/1/2023
End Date: 6/10/2025
Status: Active

2024 Funds Expended:	$150,000
Total Project Cost:	$160,000
Total PG&E Cost:	$153,200
Total Co-Funding:	$6,800

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

2.21.F CNG Locomotive Field Demonstration

The project objective was to design, build, test, and operate a pre-production, compressed natural gas (CNG) hybrid line-haul locomotive to demonstrate the Cummins Westport ISX12N natural gas, near-zero-emission engine in rail service. In 2023, the project team continued to work on locomotive design and procurement of long-term components (CNG tanks, batteries, engines, alternators, and power electronics). The benefit will be a better understanding of the potential of CNG as a locomotive fuel. The project demonstrated a Tier-5-capable locomotive built with commercially available and reliable components, illustrated the use of near-zero-emission, on-road engines for use in off-road markets, opened new markets such as rail and marine, quantified the benefits of multi-engine hybrid locomotives, reduced fuel consumption by 20% to 40%, and showcased the benefits of CNG and renewable natural gas use in rail application. These benefits include reducing fuel costs, reducing criteria pollutants, lowering greenhouse gas emissions, and collecting data to validate durability and reliability. In 2024, the team refined the module design for manufacturing. In late 2024, Cummins informed Optifuel that they would no longer provide X15N engines for the rail market. Design activities are currently on hold until a new engine manufacturer is selected and impacts can be assessed.

Co-Funders: DOE, UTD members

Start Date: 7/1/2021
End Date: 4/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$5,199,733
Total PG&E Cost:	$29,167
Total Co-Funding:	$5,170,566

Benefits

2.21.G Distributed RNG Biogas Production and Clean up Ph2

This project aims to analyze and improve the productivity of renewable natural gas (RNG) or biogas production and cleanup technologies suitable for small-scale applications handling 100s–1,000s lb waste/day, with Phase 2 focused on establishing next steps for optimizing small-scale biogas production and cleanup, working with vendors to automate system controls, identifying markets or applications for small-scale biogas units, reviewing product RNG connections to the grid or typical biogas requirements of end users, and updating economic modeling and performance optimization. During Phase 1, the project team conducted a series of unique experimental set points, where the digester was pushed to its limits. These set points allowed the team to verify long-term performance and prove the overall viability of the digester. Through some of these set points, the team began to identify areas of improvement, including additional instrumentation and online monitoring. During the over-fed stress test event, it was identified that the addition of instrumentation on the digester could provide a method to automate the operation and provide a better overall response. While some specific instrumentation was identified, preliminary investigations resulted in high equipment costs, labor-intensive processes, or products still in development. Phase 2 work will focus on key areas of improvement. The improvements have the potential to provide economic benefits by decreasing currently manually executed tasks and improving system performance by increased system automation and remote monitoring. By continuing to focus on small-scale AD, this project will enable the utilization of a wider range of applications and locations, allowing for the growth of RNG and biogas production that is needed to meet natural gas grid decarbonization goals.

Co-Funders: Chomp Energy

Start Date: 10/1/2024
End Date: 4/1/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$175,000
Total PG&E Cost:	$13,125
Total Co-Funding:	$161,875

Benefits

2.21.H Hydrogen Fueling for Heavy-Duty Vehicles

The project facilitated the installation of public high-flow H35 hydrogen stations for heavy-duty vehicles, expanding their range and operational area while enabling hydrogen to become a key component in the renewable energy mix for long-distance hauling. With no national standard for high-flow hydrogen fueling of heavy-duty trucks, the project collaborated with the National Renewable Energy Laboratory (NREL) and the U.S. Department of Energy (DOE) to develop and publish a publicly available fueling protocol. The project demonstrated that time filling—an overnight fueling method commonly used in compressed natural gas (CNG) fleets—could be conducted safely, significantly reducing the capital cost of fueling stations. Control methods were developed to ensure safe fueling, and testing confirmed the system met performance requirements. An economic analysis validated time-filling as a lower-cost fueling solution, reducing infrastructure costs and barriers to hydrogen adoption in the medium- and heavy-duty vehicle sector. The final report, published in September 2024, highlighted these advancements, providing critical technical insights to accelerate hydrogen fueling infrastructure deployment and promote hydrogen as a viable fuel source for long-haul transportation.

Co-Funders: NREL, UTD members

Start Date: 7/1/2021
End Date: 9/5/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$692,500
Total PG&E Cost:	$8,333
Total Co-Funding:	$684,167

Benefits

2.22.B Ribbon Burner with Hydrogen Blended Gas

The project aims to evaluate the performance of traditional ribbon burners operating with hydrogen and hydrogen-natural gas blends (0–100%) to determine technical feasibility, identify optimal design parameters, and address design gaps. Key performance indicators include heat release, temperature profiles, emission data, and the correlation between hydrogen content and burner performance. Based on test results and discussions with a leading ribbon burner manufacturer, the burner geometry has been modified for hydrogen combustion, and prototypes have been manufactured and shipped for testing. Further development will continue in an industrial research laboratory to refine performance and ensure safe hydrogen integration. A ribbon burner capable of handling variable hydrogen blends presents a long-term, sustainable solution for industrial facilities, such as wholesale bakeries, seeking to reduce carbon emissions. The project also explores broader decarbonization strategies integrating green hydrogen production, advanced waste heat utilization, water recovery, volatile organic compound (VOC) mitigation, and self-powered control. In 2024, due to the required facility improvements for hydrogen safety, testing has been delayed. During this period, the team has rebuilt the test apparatus with mass flow controllers and enhanced instrumentation to improve measurement precision, ensuring the project can generate reliable data to support hydrogen's role as a clean industrial fuel.

Co-Funders: UTD members

Start Date: 6/30/2022
End Date: 4/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$175,000
Total PG&E Cost:	$19,022
Total Co-Funding:	$155,978

Benefits

2.22.G Pre-Cooling for High-Flow Hydrogen Fueling

The project will develop a chilling system to pre-cool hydrogen for high-flow fueling of heavy-duty trucks at 10,000 pound-force per square inch, or 70 MegaPascals. Precooling hydrogen before fueling is vital because hydrogen has a negative Joule Thompson coefficient, which means it gets warmer when its pressure drops, unlike natural gas, which cools down. Since hydrogen is less energy-dense than diesel, fueling has to happen at a very high flow rate for the truck to have enough energy to match a full diesel tank, further increasing the risk of overheating. GTI Energy won a competitive federal solicitation process to secure $2.2M of US Department of Energy (DOE) funds for this project, with an additional contribution of $250k from SoCalGas. The project goal is a pre-cooler design capable of fueling 10 kg/min of hydrogen (equivalent to diesel fueling speeds) at less than $500,000. The project will facilitate high-flow fueling of hydrogen heavy-duty trucks at the same speed as diesel fueling. This is important as California and other states adopt aggressive zero-emission vehicle targets for heavy-duty vehicles, such as California's Advanced Clean Truck Regulation and the recently signed 15-state Memorandum of Understanding to advance the electric medium- and heavy-duty vehicles market. In 2024, the heat exchanger test unit was commissioned, and testing started in August. The test results have proven very valuable in understanding the heat exchanger performance as well as the controls for the chiller loop. Testing will continue to solidify the control scheme and ensure the performance of all components. The assembly of the full test unit at Creative Thermal Solutions is underway.

Co-Funders: DOE, UTD members

Start Date: 7/31/2022
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$2,450,000**
Total PG&E Cost:	**$58,000**
Total Co-Funding:	**$2,392,000**

Benefits

2.22.H Heavy-duty Hydrogen Truck Deployment

The project will address a critical technology gap for heavy-duty hydrogen fuel cell-powered trucks. No zero-emissions vehicle can operate more than 250 miles in one shift. This project aims to design and build a hydrogen-fueled, zero-emissions regional-haul Class 8 vehicle and demonstrate the technology for 12 months on a 400-mile route from Fontana to Lathrop, California. The team selected this range because it is representative of most intra-state freight movements. By demonstrating the viability of hydrogen fuel cell trucks as a feasible zero-emission solution for long-distance operation, the project will encourage the adoption of hydrogen-powered trucks and help create substantial demand for hydrogen as a transportation fuel. In 2024, High Voltage System commissioning was completed, and Hydrogen System commissioning is in progress. Symbio has initiated the data collection/telematics system installation plan. The demonstration is planned to start in Q1 2025.

Co-Funders: CEC, UTD members

Start Date: 7/1/2022
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$5,300,000**
Total PG&E Cost:	**$50,000**
Total Co-Funding:	**$5,250,000**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

2.23.A Decarbonizing Large Commercial and Industrial Equipment with Hydrogen

The project seeks to identify and resolve research and technology gaps for using hydrogen in various combustion equipment in commercial and large commercial and industrial (C&I) buildings and processes. It does this through experimentation to establish upper limits for hydrogen blending for 3 to 6 different equipment or equipment categories and testing up to 100% hydrogen blends. The partnership with the University of California Irvine, the Air-conditioning, Heating, and Refrigeration Institute, and the Electric Power Research Institute ensures that the research effort is based on comprehensive existing knowledge, is coordinated with other global research efforts, and has significant manufacturer involvement. Leverage funding includes $2.735M in UTD co-funding and the CEC providing the prime financing. Key project goals are to 1) identify technology and research gaps review and analysis with hydrogen, 2) establish technical upper limits for hydrogen for 3 to 6 different equipment or equipment categories through experimental tests with up to 100% hydrogen blends, and 3) demonstrate the emissions, safety, operational, and performance variation of the equipment. Of the total US emissions, the C&I sector emits about 2 billion tonnes. These emissions must be reduced to near zero in the US by 2050. Energy efficiency and conservation remain critical to reducing GHG emissions. Still, decarbonization is needed to meet these aggressive climate goals, including adapting or converting combustion equipment to use renewable or low-carbon energy carriers such as hydrogen as a combustion fuel. During 2023, the project team 1) developed draft test plans for the different equipment and submitted them to the California Energy Commission (CEC); 2) continued HAZOP analysis, job safety analysis, and review safety procedures for installation and testing; 3) continued equipment selection; and 4) designed test rigs. In 2024, draft test plans for the different equipment were developed and submitted to the California Energy Commission (CEC). HAZOP analysis for the equipment and different equipment selection is in progress. Equipment for five different categories has been identified—Boilers, Water Heaters, Industrial process heating and furnaces, and commercial cooking. Testing on an industrial furnace burner is in progress. The boiler and the water heater for H_2 blending testing have been received at GTI. Other equipment is being received to perform the testing.

Co-Funders: UTD members, CEC, SoCalGas, LCRI, secured

Start Date: 7/1/2023
End Date: 7/31/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$2,735,000
Total PG&E Cost:	$71,123
Total Co-Funding:	$2,663,877

Benefits

2.23.C Controlled Mixing Burner for Process Heating

This project focuses on the design, fabrication, and laboratory testing of an innovative 0.5–1 million Btu/hr process heating burner capable of operating on natural gas and alternate low-carbon fuels (LCFs), including up to 100% carbon-free fuels (CFFs) such as hydrogen (H_2) and ammonia (NH_3). The burner is designed to maintain consistent flame size and shape, heat release profile, emissions, and turndown capability regardless of fuel carbon content, enabling process heating applications to seamlessly integrate varying amounts of LCFs without requiring burner replacements, process control modifications, or major operator intervention. Laboratory testing evaluates performance under different furnace temperatures, fuel carbon percentages, and simulated operating conditions to determine its suitability for industrial and commercial end users seeking decarbonization solutions. The controlled mixing burner technology offers multiple advantages, including the ability to increase production at facilities with natural gas limitations, a low-cost option for fuel flexibility, and significant greenhouse gas (GHG) emission reductions. In 2024, the project team fabricated a larger volume windbox, initiated testing at firing rates between 100–500 MBH, and documented more uniform flame distribution, marking a key step in advancing this fuel-flexible combustion technology toward real-world industrial deployment.

Co-Funders: UTD members

Start Date: 7/21/2023
End Date: 6/21/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$230,000
Total PG&E Cost:	$13,600
Total Co-Funding:	$216,400

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

2.24.B Fuel-flexible Infrared Ultra-Low NOx Steam Boiler

This project focuses on developing an advanced infrared hydrogen (H_2) boiler capable of operating on 0–100% hydrogen-blended natural gas to produce high-temperature steam for food and beverage production. The boiler incorporates an AI-assisted controller, enabling seamless operation on both hydrogen and natural gas, ensuring adaptability to various fuel compositions. Designed for ultra-low emissions, the system achieves NOx levels of 3 ppm or less at 3% O_2, benefiting from a moderate combustion temperature below 1100°C. To enhance efficiency, the boiler integrates an economizer that recovers waste heat from flue gas to preheat intake air, achieving an overall efficiency of 98%. This technology aims to advance decarbonization efforts in industrial steam applications, offering high efficiency, fuel flexibility, and significantly reduced emissions for commercial and industrial users.

Co-Funders: UTD members, US DOE, WVU, SoCalGas, Fulton, CSI

Start Date: 10/1/2024
End Date: 4/30/2027
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$4,250,000
Total PG&E Cost:	$37,500
Total Co-Funding:	$4,212,500

Benefits

2.24.C FlexGen-H High Efficiency, Fuel-Flexible, Ultra-Low NOx Regenerative Burner

This project focuses on developing and demonstrating a next-generation regenerative high-efficiency burner system in partnership with an industry-leading OEM to support decarbonization in process heating and industrial sectors such as iron, steel, and aluminum. The burner is designed to operate on up to 100% hydrogen while also expanding the applicability of high-efficiency regenerative operation for industries using natural gas (NG). The system incorporates novel inserts and integrated cooling to enhance performance and fuel flexibility. Testing will evaluate hydrogen-enriched natural gas combustion alongside baseline NG operation to assess efficiency and emissions reductions. By the end of the project, the team will have demonstrated the fuel-flexible burner system at approximately 1.5 to 2 MMBtu/hr in a laboratory, validated its emissions reduction and fuel savings potential, and prepared the innovative burner assembly for field testing at host sites Finkl Steel or California Steel. In 2024, the team conducted onsite meetings at GTI with Bloom Engineering (Bloom) and Argonne National Laboratory (ANL) and held multiple technical and progress meetings. Key milestones included signing a subcontract with Bloom and a CRADA agreement with ANL, making significant progress toward a CRADA agreement with Oak Ridge National Laboratory (ORNL), and advancing burner design, test setup, computational fluid dynamics (CFD) analysis framework, market transformation planning, and DEI activities. Additionally, the team developed detailed drawings of the burner and combustion train and preliminary drawings for equipment layout, air, and fuel skids, marking a critical step toward full-scale demonstration and commercialization.

Co-Funders: UTD members, DOE, SoCalGas, Bloom Engineering

Start Date: 8/1/2024
End Date: 8/31/2027
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$4,600,000
Total PG&E Cost:	$37,500
Total Co-Funding:	$4,562,500

Benefits

2.24.E Fuel-flexible, Ultra-low NOx, Cross-cutting Omnivore Combustion System

Advance the deployment of low-carbon fuels across large commercial and industrial sectors by developing and demonstrating in both the lab and field a continuously fuel-flexible (NG, H_2, biogas, syngas, etc.) combustion system. Formal kick-off call with DOE was conducted in October 2024. The team is working through sub-award contracting.

Start Date: 10/1/2024
End Date: 10/30/2027
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$5,039,000
Total PG&E Cost:	$42,691
Total Co-Funding:	$4,996,309

Benefits

Co-Funders: UTD members, DOE, SoCalGas, Honeywell Thermal Solutions, Georgia Tech, CenterPoint Energy, Southern Company, Bright Sensors

2.24.H Hydrogen-blending at Asphalt Plants—Field Tests

This project focuses on testing and validating natural gas-hydrogen (NG-H_2) blending equipment at an asphalt plant site, including the design and installation of hydrogen storage, delivery, and end-use blending at the Graniterock facility. The demonstration aims to assess the feasibility and performance of H_2 blending in an industrial setting, supporting decarbonization efforts in asphalt production. The project team conducted a host site visit to discuss various aspects of the initiative, ensuring strong engagement on NG-H_2 blending testing. A site walkthrough was performed to evaluate potential locations for H_2 blending, equipment installation, commissioning, and testing, laying the groundwork for a successful implementation and assessment of hydrogen integration into asphalt plant operations.

Start Date: 7/1/2024
End Date: 8/14/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$5,900,000
Total PG&E Cost:	$87,000
Total Co-Funding:	$5,813,000

Benefits

Co-Funders: UTD members

2.24.I Carbon Capture Technologies for Large Commercial and Industrial Systems

This project evaluates CO_2 capture technologies across various industrial processes to determine the optimal carbon management solutions for different applications. A range of factors influence the selection of carbon capture technologies, including process compatibility, technology maturity, and cost-effectiveness. The goal is to match industrial processes with the most suitable carbon capture solutions, provide insights into technology selection criteria, identify leading technology developers, and assess the current maturity and cost considerations of these technologies. Various membrane separation, adsorption technologies, and solid sorbents have shown strong potential for capturing industrial CO_2 emissions, but further development is needed, particularly regarding temperature management and scalability. While benchmark technologies are promising, they are associated with high energy demands, reducing overall plant efficiency by 10–30%, and CO_2 capture costs range from $40 to $120 per ton, depending on the industrial process. The project explores advancements in low-cost materials, process integration, and high-efficiency capture systems to improve energy efficiency and commercial viability. The team is also identifying key companies developing carbon capture technologies, compiling information on their hardware, processes, Technology Readiness Levels (TRLs), and potential industrial applications, while mapping the current state of the industry and future development pathways for large-scale carbon capture deployment.

Start Date: 10/1/2024
End Date: 1/30/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$225,000
Total PG&E Cost:	$1,6924
Total Co-Funding:	$208,076

Benefits

Co-Funders: UTD members, Penn State, CSU, USG

5.21.k HyBlend Collaboration to Address Technical Barriers to Blending Hydrogen in NG Pipelines

This project is a joint effort of natural gas (NG) operators, research consortia, and four national labs: Sandia National Lab; Pacific Northwest National Laboratory; Argonne National Laboratory; and National Renewable Energy Laboratory, to evaluate technical and economic considerations related to transporting hydrogen (H_2) blends and other low carbon fuels using existing NG infrastructure. The efforts to increase H_2 knowledge can lead to reduced greenhouse gas (GHG) emissions, such as when coupling energy efficiency and decarbonized fuels. The project team is addressing high-priority research topics, including 1) H_2 compatibility with metals and polymers, 2) life-cycle analysis (LCA), and 3) techno-economic (TE) analysis. The project team will develop general principles for the operation of HyBlend delivery systems regarding structural integrity, assess the role of NG impurities in the degradation of metal pipelines and HyBlend for plastic pipeline degradation and lifetime predictions, perform an LCA on the technology pathways for H_2 and NG blends and alternative routes, and quantify the costs and opportunities for H_2 production and blending with an NG network, and the alternative paths. In 2021, the project team established the test conditions and materials. In 2022, the project team published the literature review and gap analysis report and completed the TE analysis. Next, the project team will complete the LCA study and develop a TE model to assess opportunities to blend H_2 at varying levels into NG pipelines using the findings of their review.

Co-Funders: OTD members, DOE, NREL

Start Date: 8/19/2021
End Date: 2/29/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$1,5050,000
Total PG&E Cost:	$150,000
Total Co-Funding:	$1,4900,000

Benefits

5.21.t Effect of Hydrogen Blended Natural Gas on the Performance of Gas Meters and Diaphragm Type SE

The objective of the project is to study the effect of hydrogen-natural gas (H_2NG) blends, with up to 20% hydrogen by volume, on the durability, safety, and performance of gas meters and diaphragm-type service regulators commonly used for residential service. Tests include durability, accuracy, leakage rates, and oxidation induction time. The research project results will aid in understanding 1) material compatibility impacts on gas meters and regulators in H_2NG blend service, 2) meter accuracy in H_2NG blends, and 3) feasible H_2NG blend limits between 0–20% for gas meters and service regulators. In 2022, the team finalized the bill of materials for three potential testing rig options. The sponsors chose two test rigs, each with nine regulators and nine meters. Construction of the test rigs began in late 2023. Project delays were due to rescoping, supply chain issues related to parts delivery, and the need to perform a comprehensive safety analysis with the development of safety protocols. The primary project deliverable will be a final report. PG&E could use the results from this research to contribute to the creation of a statewide hydrogen injection standard. In 2024, the project team was able to successfully get all 36 solenoid coils to open properly and, therefore, was able to move both test rigs outside and connect all of the plumbing between the various components of the test's flow loops. Additionally, the project team made significant progress toward connecting the majority of the wiring from the electrical components on the test rigs to the main electrical panel and connecting the high-voltage wires to the two compressors.

Co-Funders: OTD members

Start Date: 10/1/2021
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$55,000
Total PG&E Cost:	$3,906
Total Co-Funding:	$51,094

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

5.24.h Hydrogen Blending Pilot—Gas Quality Evaluation and System Modeling

The project team will partner with CenterPoint Energy to conduct hydrogen percentage and fuel property measurements (heating value, Wobbe Index, density, temperature, etc.) at 14 locations throughout the hydrogen blending pilot area in Minneapolis, Minnesota to evaluate hydrogen dispersion under dynamic conditions. In-line sensors will be installed to enable continuous measurement of hydrogen concentrations at 4 locations. A portable gas analyzer will be utilized to validate hydrogen measurements at 10 other locations. The data will then be compared to results from existing system simulation models (Synergi) and determine if model updates are needed to accommodate hydrogen blending. A year's worth of field data will be collected to evaluate any dispersion behavior differences with seasonal demand changes. The project team is in the process of ordering sensors and equipment for field installation planned in 2025.

Co-Funders: N/A

Start Date: 10/1/2023
End Date: 9/30/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$302,003
Total PG&E Cost:	$53,027
Total Co-Funding:	$248,976

Benefits

5.24.s De-blending Demonstration

This project will conduct a feasibility study for installing and demonstrating a de-blending system at GTI Energy. The feasibility study will assume a 12-month demonstration to evaluate system performance under various seasonal and operating conditions (e.g., various hydrogen blends, ambient temperatures). It is assumed that system data will be continuously collected. De-blending technologies have the potential to support large-scale hydrogen blending by protecting certain end-users that are sensitive to have elevated levels of hydrogen in their gas supplies (e.g., NGV fueling stations, LNG facilities, industrial applications). De-blending also has the potential to reduce costs and increase accessibility to hydrogen by enabling delivery of pure hydrogen via hydrogen blending in natural gas pipelines (i.e., a de-blending system is installed at an end-user to extract hydrogen from a blend to supply the end user's hydrogen needs). Figure 1 illustrates a potential scenario where de-blending technologies can be installed to protect sensitive end-users and to deliver pure hydrogen to certain applications. The project kick-off was held on September 13, 2024. A survey was sent to sponsors to obtain feedback on proposed specifications, assumptions, and system data to be collected.

Co-Funders: UTD members

Start Date: 10/1/2024
End Date: 12/1/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,108,689
Total PG&E Cost:	$4,333
Total Co-Funding:	$1,104,356

Benefits

5.24.z SUSTAIN H2 (Subsurface Storage Technological Advancements and Innovation for Hydrogen

The primary focus of the SUSTAIN H2 Project is to conduct a comprehensive assessment of large-scale UHS development across all U.S. regions, considering technical aspects such as capacity, efficiency, safety, potential infrastructure reutilization, and economic feasibility. Additionally, SUSTAIN H2 strives to furnish business developers and regulators with overarching guidelines and information to facilitate UHS's safe and cost-effective deployment. Operators with natural gas storage facilities can lead decarbonization efforts and potentially create larger carbon offsets by using their existing infrastructure to stabilize energy demand fluctuations and provide long-term storage. Natural gas operators are best equipped to use their expertise to safely store and deliver clean energy.

Co-Funders: OTD members

Start Date: 10/1/2024
End Date: 10/1/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$900,000
Total PG&E Cost:	$50,000
Total Co-Funding:	$850,000

Benefits

6.24.a Hydrogen Emissions Research Consortium (HyRes)

Hydrogen has the potential to help decarbonize difficult sectors while taking advantage of existing energy infrastructure. However, associated emissions and newly identified climate impacts of hydrogen in the atmosphere present a risk to developing a hydrogen economy. HyRes will provide the information needed to help ensure cost efficiency through informed decision-making on hydrogen emission mitigation strategies. To ensure a streamlined and low-impact implementation of a hydrogen economy, we must apply extensive lessons learned from the methane emission quantification and mitigation space to the topic of hydrogen emissions. GTI Energy hosted the first annual Hydrogen Emissions Exchange in early November at the University of Texas at Austin (HEX@TEX). HyRes hosted a Tech Talk titled HyRes: Measuring and Mitigating Hydrogen Emissions. The Tech Talk was attended by more than 200 people with over 400 registrants. HyRes submitted two scientific papers titled "Estimating the Climate Impacts of Hydrogen Emissions in a Net-Zero U.S. Economy" and "Effect of Hydrogen Leakage on the Life Cycle Climate Impacts of Hydrogen Supply Chains" in peer-reviewed journals. These papers summarize the research conducted under HyRes over the past year and are currently under review. HyRes reviewed 100+ scientific articles on hydrogen emissions. We will upload a table listing all papers along with slides summarizing key papers to the OTD Sharepoint site.

Co-Funders: OTD members

Start Date: 12/18/2023
End Date: 5/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$25,000
Total PG&E Cost:	$25,000
Total Co-Funding:	$0

Benefits

7.16.e Ph3 On-Line Biomethane Gas Quality Monitoring

The purpose of this project is to develop and test the on-line analyzer validated as best performing in Phase II for monitoring the unconventional trace contaminants found in biomethane (BM) injection if cleanup technologies fail. The focus is on the constituents that are not routinely monitored by online instruments but that are critical to pipeline integrity, end-use integrity, and human health. One of the growing concerns with biomethane is the effect on gas quality, human health, and infrastructure integrity. Upon identifying potential risks, monitoring techniques are needed to ensure safe interchangeability of the new fuel gas. By doing so, utilities can prevent the combustion problems caused by siloxanes, monitor potential carcinogens (BTEX/arsines/amines), and preserve pipeline integrity from solvation (BTEX, halogenated hydrocarbons). The project team is coordinating with Ohio Lumex and the project sponsors on prioritizing trace constituent measurements.

Co-Funders: OTD members

Start Date: 9/1/2021
End Date: 3/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$267,000
Total PG&E Cost:	$25,000
Total Co-Funding:	$242,000

Benefits

ESJ Community | Affordability | Equity | Improved Air Quality | Operational Efficiency | Reduced GHG Emissions | Reliability | Safety

7.18.h Ph3 Center for Gas Quality (Gas Quality Database)

This project is for the existing trace constituent gas quality database to continue to be updated quarterly with fresh information, including data from the literature, available lab analyses, and shared data from OTD and PRCI members. Based on feedback from sponsors, an additional module will be added. The deliverable is the updated trace constituent gas quality database. Phase 3 will continue maintenance and updates to the trace constituent gas quality database created in Phase 1 and further developed in Phase 2. The database was created to facilitate the industry's understanding of Renewable Natural Gas (RNG) trace constituents and provide background knowledge to successfully integrate RNG into their system to meet their decarbonization goals without compromising their assets. This database ensures that renewables can be integrated and do not impact system operations or safety. In 2024, the project team updated the site user guide document to reflect on the recent improvements/changes. It continued collecting user responses to surveys for new data submissions, operational issues, and new user additions to the site.

Co-Funders: OTD members

Start Date: 5/2/2023
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$75,000
Total PG&E Cost:	$6,737
Total Co-Funding:	$68,263

Benefits

7.21.d Accuracy of Hydrogen Analyzers and Survey Instruments

The project will conduct a laboratory evaluation on the precision, accuracy, and bias of analytical equipment for natural gas blended with hydrogen at concentrations between 5% and 20%. The project team will evaluate a hydrogen analysis train for ABB's Natural Gas Chromatographs (NGC) 8206 for online British thermal units (BTU) gas chromatographs. The team will select two to four current-market leak detection and leak survey instruments to evaluate the calibration impacts of lower explosive readings when measuring natural gas/hydrogen blends. Blending hydrogen into the natural gas pipeline to reduce carbon emissions has gained traction over the last several years. Many online natural gas BTU NGC manufacturers already offer a train or module for their NGCs capable of hydrogen analysis. Still, historically, the industry has not used them at custody transfer sites. As a result, the industry does not have experience with the precision, accuracy, and bias of these hydrogen analysis systems. Additionally, there is a growing concern related to the impacts of hydrogen on gas leak detection instrument performance and whether the presence of hydrogen will change gas leak results.

Co-Funders: OTD members

Start Date: 4/1/2021
End Date: 8/9/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$248,000
Total PG&E Cost:	$19,528
Total Co-Funding:	$228,472

Benefits

7.21.j Assessing Performance Impacts of Blended Hydrogen on Thread Sealants

The project aims to observe the impacts of hydrogen-blended natural gas on specific components in the distribution system. Specifically, low-pressure thread sealants are typically used on meter set assemblies. This work will leverage equipment designed and fabricated in another proposal (OTD 5.21.t). The project studied the effect of hydrogen-blended natural gas on the performance of gas meters and diaphragm-type service regulators. This project is delayed due to supply-chain issues with thread gauges, blended gas, and a lack of resources. The project team is assessed reallocating resources to reduce the delay impacts. The project team has made some progress with the Test Procedures and Job Safety Analyses (JSA). Testing is expected to begin in Q1 2024. The project once completed, will provide value by 1) establishing a baseline for understanding the effect hydrogen-blended natural gas has on elastomers and sealants within the delivery infrastructure and 2) taking advantage of and adding to a testing rig being designed and built as part of another OTD project proposal; this will highlight the ability of test rig to provide modular solutions for closed-loop testing as well as continuous monitoring. In 2024, the team completed the Job Safety Analysis form. The first set of 12 samples were constructed and tested for leaks of 125 psi. Temperature testing is on-going.

Co-Funders: OTD members

Start Date: 9/1/2021
End Date: 5/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$150,000**
Total PG&E Cost:	**$4,500**
Total Co-Funding:	**$145,500**

Benefits

7.22.L Open Hydrogen Initiative

OHI is an international research consortium with the express intent of laying the foundation for technology-neutral hydrogen markets. Through this, all forms of hydrogen production can be compared on an apple-to-apples basis, void of technology or feedstock-based biases. Phase II of OHI will focus on expanding the impact and adoption of the solutions built in Phase I. This effort will prioritize expansion of the OHI toolkit to include pipeline transportation, further refinement and improvement of the OHI toolkit, conducting a public comment period for OHI tools, exploring assurance and validation around hydrogen carbon intensity (CI) expansion of the existing toolkit to include production of ammonia, educational advocacy with regulators and policymakers, and industry convening.

Co-Funders: OTD members

Start Date: 10/1/2024
End Date: 10/1/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$50,000**
Total PG&E Cost:	**$25,000**
Total Co-Funding:	**$25,000**

Benefits

7.23.f Advancing Hydrogen Leak Detection and Quantification

OHI is an international research consortium with the express intent of laying the foundation for technology-neutral hydrogen markets. Through this, all forms of hydrogen production can be compared on an apple-to-apples basis, void of technology or feedstock-based biases. Phase II of OHI will focus on expanding the impact and adoption of the solutions built in Phase I. This effort will prioritize expansion of the OHI toolkit to include pipeline transportation, further refinement and improvement of the OHI toolkit, conducting a public comment period for OHI tools, exploring assurance and validation around hydrogen carbon intensity (CI) expansion of the existing toolkit to include production of ammonia, educational advocacy with regulators and policymakers, and industry convening.

Co-Funders: PHMSA, OTD members

Start Date: 10/1/2022
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$1,562,946**
Total PG&E Cost:	**$0**
Total Co-Funding:	**$1,562,946**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

7.23.i Net Zero Infrastructure Program (NZIP)

The Net Zero Infrastructure Program (NZIP) is a GTI Energy-led research collaboration focused on accelerating the transition to net-zero emissions by understanding how today's natural gas infrastructure can evolve to advance the development of integrated energy systems. NZIP's next 12 months will focus on developing the decarbonization and R&D roadmap for the key US regions, continuing to develop the map and data tools and conducting outreach activities (webinars and workshops) to support the program's objectives. Many studies exclude costs and fail to account for realistic infrastructure development timelines for decarbonization. NZIP aims to build off these studies and focus on infrastructure needs - addressing how integrated energy systems will evolve and how stakeholders should plan and invest in gas infrastructure through the energy transition. In 2024, the project team completed several PUC workshops, sharing knowledge on a net zero infrastructure. The team also published two short whitepapers on underground gas storage and emissions.

Co-Funders: OTD members

Start Date: 9/23/2024
End Date: 9/23/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$620,000**
Total PG&E Cost:	**$50,000**
Total Co-Funding:	**$570,000**

Benefits

7.23.k.2 Mercury Action Limits for RNG Specifications

Phase 2 of this project aims to execute the test plan developed in Phase 1 by Southwest Research Institute (SwRI) for experimental determination of the impact of vapor phase mercury on components and materials found in end-use and pipeline distribution equipment. This data can be used to inform the selection of appropriate mercury triggers and action levels for natural gas distribution systems. All test articles are prepared and ready. Fabrication of the test chamber is finished. The test setup is complete with the exception of receipt of the PS Analytical equipment to generate mercury vapor and measure its concentration. Testing is on-going.

Co-Funders: OTD members

Start Date: 1/1/2024
End Date: 12/31/2026
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$1,084,000**
Total PG&E Cost:	**$214,270**
Total Co-Funding:	**$869,730**

Benefits

Brimstone Energy Carbon Negative Cement Production

Brimstone Energy is developing a carbon-negative cement production process by changing the chemistry, so limestone is no longer used as a raw material. This process would also allow for capturing carbon dioxide (CO_2) from the air through the mineral co-product magnesium hydroxide. At the core of their technology is a chemical leaching process that takes silicate rocks as raw materials (abundant in California) and generates calcium oxide, which can be used to make clinkers for Ordinary Portland Cement (OPC). Unlike limestone, calcium oxide does not emit CO_2 when heated to high temperatures. Brimstone can run the carbon capture process at zero cost by generating revenue from OPC and cementitious materials sales. Reducing industrial carbon emissions is difficult and expensive, especially for cement manufacturers, whose two-thirds of emissions come from heating raw materials. This process will enable cement manufacturers and big natural gas consumers to achieve their decarbonization goals while using natural gas as heating fuel. In Q4 2024, Brimstone notified PG&E that they were unable to reach the 100 tonnes of sequestered carbon goal. They will continue to make low-carbon cement but will not measure or verify the passive CCS.

Co-Funders: ARPA-E

Start Date: 9/30/2021
End Date: 12/31/2024
Status: Completed

2024 Funds Expended:	**$0**
Total Project Cost:	**$13,000,000**
Total PG&E Cost:	**$25,000**
Total Co-Funding:	**$12,975,000**

Benefits

CEC GFO-20-604 Port of West Sac Hydrogen Fuel Cell Switcher Rail Demo

This leverages CEC GFO-20-604—Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports (H2RAM). GTI was awarded $4 million, and the project title is Sierra Northern Hydrogen Locomotive Project. GTI and Sierra Northern Railway are working with Group 1 partners to design, build, and demonstrate a hydrogen-fueled, zero-emission switcher locomotive. The integration of advanced fuel cell and battery technologies represents a new platform that will enable commercialization within a few years. The locomotive will be demonstrated in Sierra Northern Railway's short-line operations, which serve the rail yard and seaport in West Sacramento. Shell and Sierra Northern Railway are submitting a fully integrated Group 2 application to establish a long-term hydrogen fueling facility for locomotives and on-road vehicles consistent with CEC goals and efforts. This fueling facility will be on Sierra Northern Railway's land in the heart of their short-line operations in the Port of West Sacramento. As PG&E looks for future opportunities to decarbonize its gas system, heavy-duty transportation fueled by hydrogen is a promising solution. PG&E serving on the TAC will allow us to learn the drivers and challenges experienced while requiring no payment.

Co-Funders: CEC

Start Date: 11/1/2021
End Date: 6/30/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$9,000,000
Total PG&E Cost:	$1
Total Co-Funding:	$8,999,999

Benefits

CEC GFO-21-503 Effects of H_2 in End-Use Equipment for Comm. and Ind. App.

This project will support the CEC's GFO-21-503—Examining the Effects of Hydrogen in End-Use Appliances for Large Commercial Buildings and Industrial Applications. The objective is to conduct a technical study of the impacts of utilizing hydrogen, blended with natural gas and 100% hydrogen, in existing appliances and equipment as a decarbonization strategy for large commercial buildings and industrial processes in California. The research aims to identify and resolve key research and technology gaps through techno-economic analysis, laboratory testing and calibrated simulation of representative combustion equipment and materials, air quality modeling, and stakeholder engagement. The focus will be on understanding the cost, performance, and safety implications and the emissions benefits of adopting hydrogen in these sectors. The project team will also identify and address key benefits, challenges, and potential solutions for increasing hydrogen use in end-use equipment. GTI Energy is leading this effort with the Electric Power Research Institute (EPRI) and the University of California, Irvine (UCI) to complete this wide-reaching study. The team will establish a methodology to select equipment categories based on the magnitude of the GHG emissions associated with the type and the potential for reduction via hydrogen use. The techno-economic analysis will seek to understand the decarbonization potential of using hydrogen to fuel these equipment categories and other measures (e.g., energy efficiency) to 2035 and 2050. The team will make a comparison against business-as-usual and alternative pathways (e.g., electrification vs. diversified path).

Co-Funders: CEC, UTD members

Start Date: 11/14/2022
End Date: 11/28/2025
Status: Cancelled

2024 Funds Expended:	$0
Total Project Cost:	$3,557,500
Total PG&E Cost:	$50,000
Total Co-Funding:	$3,507,500

Benefits

CEC GFO-21-507 Hydrogen Blending in Existing Gas Networks

The solicitation aims to fund research that helps shape and develop the safety practices of blending hydrogen into the natural gas pipeline system by identifying the requirements, steps, and procedures involved. The main benefit to California is linked to the social cost of carbon ($51 per metric ton, according to the EPA8). In a 100% hydrogen scenario, Californians would save over $ 3.2 billion/year 9,10,11 on the social costs of carbon emissions alone. Moreover, if California uses the technology successfully, other states will follow, and the benefits will multiply (the benefits will spread throughout the economy and impact future generations).

Co-Funders: CEC

Start Date: 2/9/2023
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$7,250,021
Total PG&E Cost:	$1
Total Co-Funding:	$7,250,020

Benefits

DE-FE0032008 Ph2 H_2 Storage for Load-Following and Clean Power

This project advanced hydrogen (H_2) energy storage solutions to mitigate variable renewable energy (VRE) impacts on fossil-fueled assets and explored the use of low-cost electricity to generate hydrogen from fossil energy for storage and utilization during peak demands in duct-burning applications. Utilizing stored hydrogen as an energy carrier enables the system to support peak energy demands while minimizing the impact on fossil assets. The low-carbon hydrogen produced from fossil sources provides dispatchable hydrogen production at a lower cost than steam methane reforming (SMR)-based hydrogen. The project, completed in 2024, demonstrated the economic and environmental advantages of stored hydrogen utilization. Key takeaways include a 17.4% lower electricity cost compared to a combined cycle gas turbine (CCGT) plant using an SMR/amine system and a 28% lower Levelized Cost of Hydrogen (LCOH) than SMR. Hydrogen is produced from natural gas and can either be combusted or stored in roadable containers with a 54 MWhr storage capacity. The process inherently captures 90% of CO_2 emissions, with potential upgrades to achieve 98% capture. The study provided a detailed system definition, including process models, PFDs, P&IDs, a plant layout, and preliminary designs for key components and environmental considerations. The best application for the Carbon Hydrogen Generator (CHG) is in H_2-fired CCGT plants, with significant demand projected by 2035, depending on natural gas prices and capital costs. Duct burners, which are highly flexible and capable of burning any combination of hydrogen and natural gas, were identified as a logical starting point for integrating hydrogen into the power market.

Co-Funders: DOE

Start Date: 10/5/2022
End Date: 3/29/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$1,131,971
Total PG&E Cost:	$37,500
Total Co-Funding:	$1,094,471

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

Eval of Hydrogen-NG on Engine Performance and Durability

The project aims to evaluate the impact of hydrogen content in natural gas on the performance and durability of one end-use technology, the Cummins L9N 8.9 liter near-zero natural gas engine. Cummins has a set limit for hydrogen content of 0.03% by volume, a long-standing limit probably based on typical natural gas composition. Since the limit is part of the Cummins specification, using natural gas with a hydrogen content greater than 0.03% could void the engine's warranty. The University of California, Riverside (UCR) research team will operate the motor on hydrogen-blended natural gas for 500 to 1,000 hours, simulating typical heavy-duty truck and transit duty cycles. After completing the testing, the research team will disassemble the engine to identify and analyze impacts on the components, fluids, and performance. The research will provide data to justify the initiation of extensive validation work to increase the hydrogen limit for near-zero-emission natural gas engines. Increasing the hydrogen limit in Compressed Natural Gas (CNG) engines will help reduce CO_2 emissions. In 2022, UCR set up the engine on a dyno and started developing the blending system and identifying hydrogen sources and safety considerations. In 2023, the UCR team sourced all the gas storage and blending equipment and the hydrogen and CNG. They completed the installation of all diagnostic sensors on the test engine and began running preliminary steady-state baseline testing. In 2024, the project team started the durability testing. Data analysis will begin in early 2025.

Co-Funders: SoCalGas

Start Date: 1/15/2021
End Date: 6/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$489,977
Total PG&E Cost:	$125,000
Total Co-Funding:	$364,977

Benefits

G4 Insights PCH Process Confirmation Project

The project leverages the latest iteration of the process testing apparatus built by G4 Insights Inc. (G4) for its $2.2M ATCO Gas demonstration project. The project will benefit from the baseline data and operating experience acquired on the ATCO project. G4 PyroCatalytic Hydrogenation (PCH) is a proprietary thermochemical process to convert forestry biomass into renewable natural gas. PG&E is interested in evaluating the G4 PCH process for potential commercial applications. G4 will conduct a series of test runs leading to a 7-day continuous operation run. During 2023, G4 continued its scaled-up PCH Reactor project to achieve 3 tons/day biomass. G4 also began to focus on government and industry grants to supplement current funding, continued to seed strategic partners and secure a commercial site and project developers. The project team will collect, analyze, and share data with PG&E in a final report. In 2024, G4 Insights sorted issues with the biomass feed, pyrolysis, and conversion subsystems, worked on the catalyst regeneration subsystem, and made instrumentation changes.

Co-Funders: ATCO

Start Date: 2/15/2022
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$80,000
Total PG&E Cost:	$40,000
Total Co-Funding:	$40,000

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

JEFI-00-02—EFI Guidance Document

The EFI Guidance Document covers a comprehensive resource for use by pipeline and storage operators, standards organizations, and regulators on the unique aspects of new and repurposed hydrogen pipeline systems and storage assets in varying environments compared to natural gas pipelines and storages with respect to seven topics: safety (Section 2), integrity (Section 3), inspection and maintenance (Section 4), compression (Section 5), measurement (Section 6), network components/blending (Section 7) and underground storage (Section 8). Each of the section is organized based on the following three levels: 1) High-level considerations 2) Detailed Considerations in Implementation of Existing Codes and Guidelines 3) Recommendation of Updating Current Codes and Guidelines.

Co-Funders: PRCI members

Start Date: 8/1/2023
End Date: 11/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$350,000
Total PG&E Cost:	$1
Total Co-Funding:	$349,999

Benefits

JEFI-01-02 Electrical Area Modeling and Risk Assessment of Hydrogen-Natural Gas Blends

One of the key emergent technologies for large-scale hydrogen deployment application is the blending of hydrogen into existing natural gas pipelines. In the US, most of the natural gas pipeline systems were installed in the 1950–60's and during a more recent construction surge. Natural gas pipeline systems have many key components in addition to the pipe itself. These facilities include compression stations, city gate stations, and storage facilities. The Pipeline Research Council International, Inc. (PRCI) brings together leading energy pipeline companies to perform research and development to confront pressing challenges facing pipeline systems. PRCI has identified a need to inform regulators and relevant codes and standards on safe operations of pipelines transporting mixtures of natural gas and hydrogen, commonly referred to as blending. This requires the evaluation of all components and systems associated with natural gas pipelines and potential hazards associated with injection of hydrogen at various blend ratios and hydrogen partial pressure. Research under this CRADA will address several of the risks associated with blending hydrogen into the natural gas pipeline system, specifically hydrogen leak scenarios and electrical classification at compressor stations. The modeling capabilities developed through this project will leverage existing science and engineering frameworks (e.g., HyRAM/HyRAM+) to assess risk of H_2/NG blends in compressor stations and provide a foundation to further development of codes and standards to ensure the safety of blended gas systems. Developing the capability for HyRAM+ to model blended gas releases and perform quantitative risk assessments for a relevant subsystem will provide a path for permitting blended gas in the natural gas infrastructure. Additionally, investigation into the electrical code requirements and documentation of necessary facility modifications (if any) will demonstrate the issues and remediation necessary to advance options for blending hydrogen into existing natural gas assets. These tasks will provide industry with the appropriate data and a template for science-based decision-making for blending hydrogen into natural gas toward pathways toward decarbonization.

Co-Funders: PRCI members

Start Date: 1/1/2023
End Date: 11/6/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$70,000
Total PG&E Cost:	$1
Total Co-Funding:	$69,999

Benefits

JEFI-02-02 Develop H_2/NG Composition Analysis Tools

The objectives of the proposed Project are to validate the suitability of commonly used gas composition tools in the presence of hydrogen to identify a suitable technology provider(s) and construct a workplan to develop a field-compatible hydrogen and/or hydrogen natural gas blend analysis tool (preferably portable) that can measure the calorific value and concentrations of natural gas constituents and hydrogen at regulated threshold levels. A subsequent program objective would be to work collaboratively with other gas company users/developers implementing hydrogen blending plants to use the developed tool to inform the industry about the presence of hydrogen in equipment that uses hydrogen natural gas blends (up to and including 100% hydrogen). The goals are twofold. First, validate commonly used traditional natural gas composition analysis tools in the presence of hydrogen to determine if modifications or new tools are needed. Second, research and development are needed to advance gas composition analysis to accurately measure hydrogen blending parameters. Current gas chromatographs are generally incapable of accurately measuring hydrogen levels, while certain solutions under development (i.e., using light and sound measurement) are in the early stages of research. Billings and some flow metering techniques require accurately evaluating gas composition and calorific value (BTU). Considering the challenges of maintaining a constant hydrogen blend level in the pipeline and for sensitive end-users, developing an accurate, live assessment of gas composition/calorific value is important. Some tools have been developed that apply to up to 10% hydrogen. However, further validation and development of specialized tools for higher blend levels are required. In 2024, GRTGaz continues to acquire the necessary gas cylinders, lab preparation, and analyzers for testing.

Co-Funders: PRCI members

Start Date: 12/1/2023
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$328,000**
Total PG&E Cost:	**$1**
Total Co-Funding:	**$327,999**

Benefits

JEFI-03-01 DNV JIP Guidelines Integrity Mgmt H_2 Pipelines

The project focuses on developing guidelines for assessing pipeline defects for transporting hydrogen-blended natural gas. The guidelines will be based on compiling information from various ongoing industry efforts and developing specific information on relevant materials under representative environmental and loading conditions. The guidelines will provide a framework to assess the feasibility of transporting hydrogen blends in existing pipelines and provide a basis for constructing new pipelines for hydrogen service. The benefits include 1) properties of relevant fatigue crack growth rate (FCGR) and fracture toughness (FT) in relevant environments and loading conditions, 2) the role of metallurgical variables on the FCGR and FT parameters in hydrogen to enable the development of guidelines for defect assessment in existing as well as new pipelines, and 3) an integrity management framework based on representative properties of relevant materials in typical operating environments. In 2023, the project team completed several in-situ fracture mechanics tests to understand hydrogen interactions with defects. In 2024, DNV continued to conduct experiments.

Co-Funders: PRCI members

Start Date: 7/15/2022
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	**$0**
Total Project Cost:	**$350,000**
Total PG&E Cost:	**$1**
Total Co-Funding:	**$349,999**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

JEFI-03-04 CO School of Mines—Technologies for Enabling the Safe and Efficient Trans of H_2 in US

The project objective is to determine the influence of microstructure on steel line pipe qualification metrics for H-blended gas environments at higher strength levels than conventionally used for these applications, e.g. X65 and X70 grade steels. Alloys and Characterization: We will obtain X65 and/or X70 grades from Evraz North America, processed to have variations in microstructure but comparable strength levels. The microstructures of these grades will be characterized using optical and electron (scanning and transmission) microscopy to characterize grain size, phase distribution, and microstructural banding characteristics. Electron backscatter diffraction will be employed to evaluate texture, boundary types, and local misorientations related to variations in dislocation density. X-ray diffraction will be used to measure dislocation density and possibly texture. Heat-Affected Zone Simulation: We will subject these grades to thermal profiles representative of weld heat-affected zones and characterize the resulting microstructures. The microstructures will be characterized in a similar manner to the base metal. Hydrogen Embrittlement Testing: Fracture toughness will be investigated in environments simulating blended gas environments, e.g. as expected in hydrogen transport blended with natural gas, and select conditions will be tested in actual blended gas environments to compare to the simulated conditions. Sandia National Laboratory will perform tests in high-pressure environments with 2–3 different partial pressures of hydrogen mixed with Ar gas, i.e., simulating different hydrogen pressures during hydrogen transport. The fracture surfaces will be characterized at Mines. These fracture toughness results will be correlated to the alloy microstructures. Similarly, fracture toughness tests on select conditions will be conducted at other external facilities, e.g. CFER Technologies, in blended gas environments to evaluate their performance in a closer simulation of actual environments and compare to tests performed at various hydrogen partial pressures at Sandia.

Co-Funders: DOE funded 80% ($1.5M total). EFI agreed to pay $40k ($20k/year)

Start Date: 6/1/2023
End Date: 6/30/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,500,000
Total PG&E Cost:	$1
Total Co-Funding:	$1,499,999

Benefits

JEFI-04-01 EWI JIP Material Qualification New Steel Pipe H_2

This Program evaluated Option B of the American Society of Mechanical Engineers (ASME) B31.12 standard. Option B required a series of tests to characterize the effects of hydrogen embrittlement on toughness and fatigue resistance in the pipe body, seam welds, and the seam weld heat-affected zones (HAZs). The fracture toughness and fatigue crack growth rate test methods specified in B31.12 were highly conservative and did not explicitly address aspects specific to parent pipe, weld, or HAZ test protocols. For example, guidance on notch placement in welds and HAZs was non-specific. Test specimen constraints, loading rates, notch depths, and other factors that could potentially influence toughness properties had important implications for the integrity and safety of pipeline operations. The scope of work addressed some of these gaps to identify best practices for quantifying fracture toughness in pipelines and their associated welds and HAZs for gaseous hydrogen service. ASME B31.12 provided conservative methodologies for qualifying pipe steels and welding procedures for hydrogen pipelines, which effectively minimized integrity threats to hydrogen lines. However, the anticipated expansion of the hydrogen pipeline network was expected to increase the need to operate these pipelines at higher pressures than had been typical for existing hydrogen lines. Approaches to qualify future hydrogen lines for higher operating pressures were critical gaps that this project sought to address. These higher pressures and design factors were considered necessary for the economic performance of the pipeline, given the longer distances over which hydrogen would be transported and the lower energy density of hydrogen gas compared to natural gas. This Program was cancelled in 2024.

Co-Funders: PRCI members

Start Date: 9/7/2022
End Date: 6/10/2024
Status: Cancelled

2024 Funds Expended:	$0
Total Project Cost:	$340,000
Total PG&E Cost:	$34,000
Total Co-Funding:	$306,000

Benefits

JEFI-04-05 DNV GL In Service Welding H_2/NG Pipelines

This project's objectives were to determine if welding onto an in-service pipeline containing a mixture of methane and hydrogen increases the risk of hydrogen cracking and, if so, develop guidance on measures that can be taken to mitigate the increased risk.

Start Date: 1/1/2023
End Date: 4/22/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$90,000
Total PG&E Cost:	$1
Total Co-Funding:	$89,999

Benefits

Co-Funders: PRCI's EFI members

JEFI-04-08 Full Scale Testing of Pipe for Hydrogen Service

This project focuses on full-scale testing of pipeline samples containing defects. Hydrogen embrittlement effects occur in metallic materials in gaseous hydrogen environments. These are typically a reduction in ductility, accelerated fatigue crack growth, and reduced fracture capacity of pipeline material, although the material strength is largely unaffected by gaseous hydrogen. The impact of hydrogen on pipeline integrity requires a combination of environmental, material, and stress mechanisms to act concurrently and increase susceptibility to fatigue and fracture failures. The existing natural gas pipeline infrastructure for hydrogen/natural gas blend operations is being considered. Natural gas transmission pipelines designed and constructed to ASME B31.8 typically operate at higher stress levels (typically 72% SMYS and sometimes higher) and wider pressure fluctuation ranges than hydrogen pipelines designed and constructed to ASME B31.12. Pipe manufacturing processes for older pipelines resulted in metallurgical and manufacturing-related features where the impacts of H_2 are not well understood. Time-dependent defects such as dents, corrosion, and cracks are also expected to behave differently in hydrogen service. These manufacturing and time-dependent features need to be tested in full-scale H_2 service to determine whether legacy natural gas transmission pipelines can be safely operated over the long term in H_2 service. In 2024, DNV completed a comprehensive NDE of candidate pipes, reviewed defect data, completed seal verification with hydrogen, finalized the fixture design for selected pipe sizes, and received/implemented a gas compression system. In 2025, DNV will prepare specimens, manufacture remaining components for full-scale testing, complete dent application trial, complete defect definitions for wrinkle bend, hard spot, and lamination fixtures, perform material property evaluations, complete design setup for in-situ wrinkle bend testing, and initiate a full-scale test of SCC specimen in water and hydrogen.

Start Date: 10/5/2023
End Date: 7/31/2026
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$2,600,000
Total PG&E Cost:	$1
Total Co-Funding:	$2,599,999

Benefits

Co-Funders: Alberta Innovate funding, PRCI members

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

JEFI-04-11 Develop Pipeline Industry Consensus Engineering Requirements (CER) for Hydrogen Transmiss

The objective of this project is to develop guidance to be used as an overlay appendix to ASME 31.8, similar to that developed for sour gas service. In ASME terminology, this is an exception chapter. Key inputs into this deliverable will incorporate recent and ongoing research in the following areas: 1) Develop and/or validate technology and analytical processes capable of confirming pipeline material properties for pipeline integrity assessments. 2) Identify processes to confirm the fundamental integrity and safe operation of vintage pipelines by expanding the applicability and reducing the uncertainty of current Fitness for Service methodologies, including the definition of critical feature dimensions, associated models and response criteria. 3) Develop, demonstrate, and validate pipeline repair systems, including those that can be deployed on in-service facilities. Determine the useful life and safe operating envelopes of such repair systems. 4) Define, understand, and improve the key practices, including models, involved in the design, construction, and integrity management of pipelines and related facilities. This work will significantly improve the application of fit-for-purpose engineering to hydrogen/natural gas blend and hydrogen transmission pipeline requirements over what is currently available in ASME B31 Standards. An initial techno-economic study indicates the reduced cost of material alone to be in the tens of millions of dollars for a pipeline system that is several hundred miles long.

Co-Funders: PRCI members

Start Date: 8/1/2023
End Date: 6/30/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$400,000
Total PG&E Cost:	$1
Total Co-Funding:	$399,999

Benefits

JEFI-05-01 DNV JIP Material Selection Underground Storage

The project focused on ensuring the integrity of underground storage facilities transitioned to hydrogen-blended service by 1) developing an understanding of damage mechanisms, 2) building models for quantitative damage prediction in low-strength materials in the presence of hydrogen, 3) improving engineering practices, 4) transitioning from allowable stress-based design to a fracture mechanics approach, and 5) improving inspection methods. The project team aimed to achieve these objectives by 1) characterizing the damage response of the various materials of interest in hydrogen storage applications to both environmental and loading variables, 2) developing an appropriate fracture mechanics framework to incorporate the material damage mechanisms, and 3) leveraging existing data on various materials in sour environments as well as seawater under cathodic protection conditions to help correlate materials data to long term in-service performance. In 2023, the project team discussed the operational conditions, environmental conditions, and potential materials that should be tested. In 2024, the project was completed.

Co-Funders: PRCI members

Start Date: 8/19/2022
End Date: 9/30/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$300,000
Total PG&E Cost:	$1
Total Co-Funding:	$299,999

Benefits

JEFI-05-02 SHASTA Participation

The project objective is to address technological hurdles and develop technologies to enable public acceptance of subsurface storage of pure hydrogen and hydrogen/natural gas fixtures as a safe and effective bulk energy storage option. SHASTA participation will allow the EFI to access a large amount of underground storage research on hydrogen service.

Co-Funders: DOE funded the entire project

Start Date: 1/1/2023
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$0
Total PG&E Cost:	$1
Total Co-Funding:	-$1

Benefits

M2018-011 Ph3 Scaling of Microbial P2G Conversion

The proposed Phase III effort aims to build, test, and scale a new generation of advanced bioelectrochemical reactors for high current density Power-to-Gas conversion at high energy efficiency exceeding the current state-of-the-art efficiency values. Stanford University and a collaborating research group at Aarhus University in Denmark will complete this work. There is a need for long-term storage of excess renewable electrical energy. In addition, conversion of renewable power to renewable natural gas from carbon dioxide is an emerging platform for producing carbon neutral methane. This technology addresses this need, by using an electromethanogenic system to convert excess renewable electrical energy into renewable natural gas while capturing carbon dioxide. In 2024, Stanford University is focused on optimizing the biological conversion of hydrogen to methane while Aarhus University is focused on optimizing the electrochemical module to be integrated with the methanogenesis module.

Co-Funders: NYSEARCH members

Start Date: 9/7/2023
End Date: 12/7/2025
Status: Active

2024 Funds Expended:	$18,263
Total Project Cost:	$339,000
Total PG&E Cost:	$39,617
Total Co-Funding:	$299,383

Benefits

M2020-008 Study Impact Trace Constituents in RNG

The objective of the proposed Project is to study the impact of trace constituents in Renewable Natural Gas and traditional pipeline gas on LDC infrastructure and customer appliances. The goal of the project is to determine appropriate trigger limits for the deleterious trace constituents to preclude any safety or maintenance risks on LDC infrastructure and gas appliances. This testing will help us reduce uncertainties and variations in limits set by different utilities for the trace constituents in RNG by providing scientific data to back up the trigger limit recommendations. In light of growing demand for RNG production and injection into distribution infrastructure in North America, the testing should help both producers and developers to help determine the optimum upgrading and measurement system for biomethane. For LDCs, it will aid decision making and help advance specifications to address safety and reliability issues. In 2024, the project team conducted ammonia appliance testing and began organohalide testing.

Co-Funders: NYSEARCH members

Start Date: 1/15/2021
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$606,810
Total PG&E Cost:	$71,390
Total Co-Funding:	$535,420

Benefits

M2021-005 Odor Detection Study—Effect of Hydrogen Blends on Odorizing NG

The objective of this project was to determine the detectability and recognizability of some primary natural gas odorant/odorant blends (e.g. TBM and 50/50 blend of TBM/THT) in the presence of hydrogen. Odorization of natural gas is one of the most significant public health advances of the 20th century and has been shown to be the optimal method to provide warning of a gas leak. Having the scientific knowledge of how blended H_2 into natural gas affects various populations' ability to detect odorized natural gas and recognize that odor as representative of the presence of natural gas is vital in preserving public safety. Key takeaways from the final report: 1) Participant Data: The analysis was based on data from 20 participants who completed enough trials to estimate detection/recognition thresholds; 2) Threshold Calculation: Thresholds were calculated as the concentration associated with 66.7% correct responses; 3) MANOVA Results: No significant differences were found between the experimental groups and the control group (all p-values > 0.1); 4) Background Gas Impact: The presence of methane, hydrogen, or their blend did not alter the detection and recognition accuracy of TBM; and (5) Phase 2C-S Testing: Similar results were observed for Scentinel E, with no significant statistical differences between conditions. In summary, the background gases did not affect the detection or recognition thresholds for either TBM or Scentinel E.

Co-Funders: SoCalGas, NYSEARCH members

Start Date: 9/21/2021
End Date: 3/31/2024
Status: Completed

2024 Funds Expended:	$0
Total Project Cost:	$294,755
Total PG&E Cost:	$46,651
Total Co-Funding:	$248,104

Benefits

M2021-008 Hydrogen Living Lab

The project aims to analyze and report data on the impacts of hydrogen blending at higher-volume percentages (i.e., 25%–35%) by evaluating the safety, maintenance, and emergency response impacts on gas infrastructure. This in-house project is co-funded by NYSEARCH. The Living Lab demonstration aims to validate the feasibility of blending 25%-35% hydrogen by volume into the existing natural gas infrastructure by simulating system operations with steel and plastic pipelines and components, a pressure regulator station, and a compressor. The project also tests the sensitivity and performance of several leak detectors. The project started with developing a test plan and requesting that sponsors begin collecting plastic and steel pipeline components for testing. Delays with compressor skid and engineering design have pushed the lead time for procurement of goods, with commissioning now scheduled to begin in late 2024. Testing will start afterward and will run for two years. This project will yield valuable data to PG&E on hydrogen blending impacts concerning safety and pipeline integrity, measurement, regulation, and procedures for safety and maintenance. In 2023, the project team developed and iterated the Test Plan. In 2024, the project team completed the siting assessment and engineering design. Major components were purchased, and the inlet scrubber was fabricated. The control panel and compressor skid are in the process of being fabricated. Construction and commissioning are planned for the first half of 2025.

Co-Funders: NYSEARCH members, SoCalGas

Start Date: 5/4/2022
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,222,402
Total PG&E Cost:	$83,855
Total Co-Funding:	$1,138,547

Benefits

MEAS-15-04/OTD 7.16.g.2 Efficacy of Offline and Online Methodologies to Measure Siloxanes in RNG Ph2

The objective of the project is to develop a universal industry-wide sampling and analysis procedure for measuring the presence of siloxanes in biomethane. The project team is developing this procedure in collaboration with the American Society for Testing and Materials (ASTM) Committee on Gaseous Fuels. As PG&E looks to accept renewable natural gas from sources such as landfills and wastewater treatment plants that may transfer siloxanes, it will be important to be able to accurately measure and analyze the siloxane concentration with an online instrument and in the laboratory. Siloxanes can be detrimental to downstream end-user equipment and can cause premature failure. Siloxane presence is a unique problem to renewable natural gas since it can be derived from landfills and wastewater treatment plants. PG&E has not injected renewable natural gas into pipeline infrastructure, but there is currently no ASTM method for measuring siloxane concentration. In Phase 1, the project team developed and published the ASTM Standard D8230 for measuring Volatile Silicon-Containing Compounds in a Gaseous Fuel Sample Using Gas Chromatography with Spectroscopic Detection. ASTM requires the performance of an Interlaboratory Study Program (ILS) within five years of the standard publication date. In Phase 2, the project team will complete the ILS and field-test an online siloxane analyzer. Initially, the scope of work only included one field test, but the project team added a second field test in collaboration with Pipeline Research Council International's MEAS-15-04 project. In 2023, the team continued with the ASTM D8230 ILS by confirming siloxane components and concentrations in the ILS gas mixture. The team received an updated analyzer and started testing to validate that the hardware and calibration issues had been resolved. The discussions on the field demonstration schedules are ongoing, as the project had delays due to equipment and supply chain issues. PG&E intends to use the research to determine the repeatability and reproducibility levels of the siloxane analysis. Once approved, PG&E will use the ASTM standard to validate the trigger level for siloxanes. This research will also help bridge the technology gap to monitor siloxane concentration levels online in real-time at sites using renewable natural gas. In 2024, the project team is conducting field measurements at 2 sites.

Co-Funders: OTD members

Start Date: 5/22/2019
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$253,000
Total PG&E Cost:	$49,608
Total Co-Funding:	$203,392

Benefits

NSF 22-546 Four Networks for Geologic H_2 Storage

The project focuses on creating 1) community engagement networks to allow community priorities to inform natural, physical, and social science research around geologic hydrogen storage, 2) an international network of experts to develop a public, open-science research plan for a field research study of geologic hydrogen storage, and 3) an inclusive hydrogen education network. Hydrogen from renewable energy will provide opportunities for transitioning energy-intensity industries to carbon-free energy, a critical step for combating the climate crisis. Establishing geologic storage in porous rock reservoirs would unlock distributed capacity for hydrogen hub development. This project addresses critical scientific, environmental, and socioeconomic questions associated with the proposed development of geologic hydrogen storage in porous rock.

Co-Funders: NSF

Start Date: 12/1/2022
End Date: 12/31/2025
Status: Active

2024 Funds Expended:	$0
Total Project Cost:	$1,500,000
Total PG&E Cost:	$1
Total Co-Funding:	$1,499,999

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

T-792 Ph1 Market Study/Technology Assessment of High Concentration Hydrogen Leak Detector

The objective of the proposed project is to determine what technologies are available or need further adaptation to meet specifications for stationary and/or mobile leak survey instruments to detect up to 100% H_2. The first part of the proposed work will focus on technical and economic requirements for detection of H_2 at volume percentages of 20, 30, 50 and 100%. There are four small tasks proposed as part of this market and technology assessment work. The specifications that are important to the funders will be reviewed and agreed upon prior to the State-of-the-Art market survey. In Task 2, the survey will be completed and technologies that meet the specifications would be identified and evaluated for commercial readiness and Technology Readiness Level (TRL) if not already commercial. The funders would be presented with technology descriptions and with the input from the funders, the most promising options would be shortlisted. Then in Task 4, the work that would be needed would be examined and then described in the form of an R&D roadmap. H_2 reduces the carbon footprint. This project would potentially provide a shorter-term solution for H_2 leak detection that if implemented could ensure safety, and save time and money to aid the transition should blends of concentrations of H_2 greater than 20% be chosen. GRTGaz/RICE performed an initial survey of instruments and sensors capable of detecting hydrogen at levels of 20% blended gas through 100% H_2, identifying 36 manufactures with 40 potential identified detectors. A broad selection of H_2 instruments and sensors considered types of sensors, advantages/limitations and TRL based position from basic principles of a sensor (TRL1) to fully developed, commercially available proven instruments (TRL9).The initial 40 potential identified detectors were reduced to five (5) based on acceptance criteria and the greatest potential for becoming an acceptable H_2 detection tool for field use.

Co-Funders: NYSEARCH members

Start Date: 1/2/2023
End Date: 3/29/2024
Status: Completed

2024 Funds Expended:	**$0**
Total Project Cost:	**$71,127**
Total PG&E Cost:	**$34,572**
Total Co-Funding:	**$36,555**

Benefits

T-794 Crack Assessment of Squeeze Off Locations with Blended Hydrogen

The objective of the proposed Project is to examine whether hydrogen blended with natural gas has the potential to leak from flaws induced by pipe squeeze-off operations on medium-density and high-density polyethylene (MDPE/HDPE). The test design would consider the various plastic pipes installed for gas pipelines over the past 40 years. For the test design, the contractor would assume that blended hydrogen gas will flow throughout the existing distribution pipeline infrastructure. This is to include a pipe sampling based on the year of installation (age), material, and diameter as a basis for selection. PG&E is interested in understanding the effects of hydrogen blending into existing natural gas pipelines. This project will provide essential knowledge, contributing information to a larger group of physical considerations and concerns that may impact existing pipeline infrastructure. PG&E prepared several pipe samples to contribute to the project for testing. In 2024, the project team gathered 15 pipe samples, with an additional 7 samples expected from another funder. The majority of the samples are from 1980 onward. Once all the samples are received, then a funder call will be held to discuss testing.

Co-Funders: NYSEARCH members

Start Date: 7/1/2023
End Date: 8/11/2025
Status: Active

2024 Funds Expended:	**$577**
Total Project Cost:	**$160,075**
Total PG&E Cost:	**$15,615**
Total Co-Funding:	**$144,460**

Benefits

ESJ Community · Affordability · Equity · Improved Air Quality · Operational Efficiency · Reduced GHG Emissions · Reliability · Safety

T-795 Standardized Hydrogen Blending and Injection Skid for LDCs

The project seeks to pioneer a digital database to provide a common framework for hydrogen blending and interconnection. This would allow utilities to select the optimal design for their systems as they begin to accept hydrogen and control blend percentages and hydrogen volume consistency throughout the distribution system. The database would serve as a valuable resource for local distribution companies as the gas industry continues to evaluate and fully understand the impact of hydrogen on the gas utility system and would help establish best practices for hydrogen system planning using this database tool. As part of the scope of work, the California Environmental Policy Council (CEPC) would develop standard process flow diagrams, pipeline and instrumentation diagrams, and fabrication drawings. Utilities could choose the skid that best fits their needs and select customized instrumentation and equipment from the database. CEPC also proposes to develop a manufacturing specification that would accompany the skid design to guide the skid's fabrication. NYSEARCH and its members are investing early to develop a standard approach to hydrogen blending and injection to minimize cost and maximize the opportunities for hydrogen interconnection with Local Distribution Companies. Utilizing a standard design and approach should save on design and development costs and make procurement of materials, testing, and commissioning of a hydrogen blending and injection skid, and development of record drawings (as-builts) more accessible. The project team has prepared drawings and documents to review. PG&E provided design comments and feedback. In 2024, the project team completed the final design package and database/selector tool.

Co-Funders: NYSEARCH members

Start Date: 7/1/2023
End Date: 3/31/2025
Status: Active

2024 Funds Expended:	$22,856
Total Project Cost:	$438,799
Total PG&E Cost:	$42,799
Total Co-Funding:	$396,000

Benefits