Application: A.22-09-006
Witness: P. Kabir
Chapter: 3

PREPARED DIRECT TESTIMONY OF POOYAN KABIR

ON BEHALF OF SAN DIEGO GAS & ELECTRIC (THE SDG&E HYDROGEN BLENDING DEMONSTRATION PROJECT)

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

March 1, 2024

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I. PURPOSE

The purpose of this chapter's testimony on behalf of San Diego Gas & Electric Company (SDG&E) is to provide details on the proposed SDG&E Hydrogen Blending Demonstration Project (Project).

This chapter will discuss: (1) the purpose of the proposal, (2) the design, equipment, construction, and decommissioning details of the proposed Project, (3) the Project testing and demonstration plan, (4) data collection and analysis, (5) Project guidance on technical, operational, and safety information as well as stakeholder feedback, (6) compliance with Decision (D.) 22-12-057, and (7) cost estimates of the Project.

The purpose of the Project is to provide operational and system-level data for the live blending of hydrogen gas in an isolated custom-built medium-pressure polyethylene (PE) distribution pipe loop in a moderate coastal climate.[1, 2,3] Testing PE pipe is critical for SDG&E as this is the most common pipeline material in our system.[4] The Project plan is to begin with an initial hydrogen blend of five percent by volume and gradually increase to 20 percent over the testing period.

The proposed Project location is on the property of the University of California, San Diego (UCSD). UCSD is a committed Project host and collaborator. UCSD is one of the world's leading public research universities and already supports numerous clean energy projects and demonstrations as part of its commitment to being a "living lab."[5] The idea of collaborating with a major research university to conduct safe and innovative hydrogen blending pilots was

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1 Medium pressure is defined as 60 pounds per square inch gauge or lower.

2 *See* Weather Spark, *Climate and Average Weather Year Round in La Jolla*, *available at:* https://weatherspark.com/y/1809/Average-Weather-in-La-Jolla-California-United-States-Year-Round.

3 Pipeline Research Council International, *PR-720-20603-R01 Emerging Fuels - Hydrogen SOTA Gap Analysis and Future Project Roadmap, available at:* https://www.prci.org/Research/Measurement/MEASProjects/MEAS-15-02/178529/202786.aspx.

4 U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration, *Annual Report for Calendar Year 2021 Gas Distribution System* (March 2022), *available at:* https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/gsrb/annual-reports/sdge-2021---sdge-dot-d.pdf.

first proven successful in the United Kingdom with the HyDeploy Keele University project. That project trialed blending up to twenty percent hydrogen in a private distribution gas system for 18 months and was completed in 2021.[6]

The collective work of SDG&E, Southern California Gas Company (SoCalGas), Southwest Gas Corporation (Southwest Gas), and Pacific Gas and Electric Corporation (PG&E) (collectively, the Joint Utilities) will help inform a future hydrogen blending standard that focuses on safety, system integrity, and reliability, as well as adheres to the Project requirements set out by D.22-12-057 and D.21-07-005.

II. PROJECT DESCRIPTION

The SDG&E Project is unique and differentiated in that it seeks to understand the impacts of hydrogen blending in state-of-the-art PE pipe in moderate coastal conditions. The Project will blend hydrogen into a custom-built medium-pressure natural gas distribution pipeline loop isolated from the central gas system. The blended gas will be consumed by a fuel cell owned and operated by SDG&E, that will feed power onto the SDG&E grid. A candidate location used for the preliminary design in this application is a UCSD parking lot southeast of Genesee Ave and Campus Point Drive (Voight Parking Lot) in San Diego, CA. This site may be subject to change to another location on UCSD property. With slight modifications, the project design is suitable to be placed at alternative candidate sites. A final site is to be agreed upon no later than March 31, 2025. SDG&E's partnership and plans with UCSD are formally recognized in a Memorandum of Understanding (MOU).[7]

The Voight Parking Lot candidate location was determined after engagement and vetting with UCSD staff and the UCSD Fire Marshall and was found to be consistent with pertinent safety and technical requirements. Refer to Figure 1 for details. This Project can be relocated to another location on UCSD's property, should that be required, depending on UCSD's ongoing renovation and construction plans. Any alternative location would have to meet the same standards and specifications as the location used in the preliminary design, as well as meet the following criteria: (a) SDG&E design purposes; (b) reasonable proximity to existing SDG&E gas and electric grid tie-ins; and (c) reasonable alignment with SDG&E cost estimates.

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[6] *See* HyDeploy Phase 1, *available at:* https://hydeploy.co.uk/project-phases/.

[7] Refer to Exhibit 3B for Amended and Restated Memorandum of Understanding with UCSD (2024).

SDG&E will investigate the impacts of blended hydrogen on at least two typical types of PE pipe in the test loop. The PE will be new, state-of-the-art PE meeting current industry standards and specifications (*i.e.*, ASTM D3350-21).

The Project test period will begin by establishing a 100 percent natural gas baseline in the new pipeline loop. In this way, SDG&E will benchmark PE pipe performance to compare and characterize any potential future degradation resulting from hydrogen blending. Once that baseline is established, SDG&E plans to blend and inject hydrogen produced onsite via an electrolyzer into the system, starting at five percent hydrogen and transitioning to 20 percent over time. The Project team will gradually increase hydrogen in the blend as the testing progresses. The team will evaluate key impacts on related equipment, including the blending skid, transmitters, pipes, valves, meters, connections, and the fuel cell. The composition of the blended gas will be monitored with a gas chromatograph, which will detect and report the percentage of hydrogen in the blend, ensuring the accuracy of the blend composition throughout the process. SDG&E is committed to operating this Project in an environmentally responsible manner. SDG&E will follow all local permitting guidelines. Water for the electrolyzer will be sourced from city water. All electricity used to produce and blend hydrogen related to the Project will be sourced from the grid. SDG&E plans to purchase renewable energy credits (RECs) to offset carbon emissions related to grid electricity use for the Project. This method aligns with the proposed clean hydrogen production tax credit regulations under Section 45V of the US Department of Treasury Internal Revenue Service Code, which allows for Energy Attribute Certificates (EACs), including RECs, to be purchased to offset the related carbon emissions from clean hydrogen production.[8]

Following the Pre-development phase, the Project will be divided into four chronological phases. Upon conclusion of the testing period, hydrogen-related equipment deployed for the testing program will be decommissioned, and SDG&E will evaluate the best use and/or disposition of the equipment and necessary site restoration.

[8] 88 FR 89220 (Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election to Treat Clean Hydrogen Production Facilities as Energy Property), *available at:* https://www.federalregister.gov/documents/2023/12/26/2023-28359/section-45v-credit-for-production-of-clean-hydrogen-section-48a15-election-to-treat-clean-hydrogen.

A. Summary of Project Phases and Schedule

Here, SDG&E outlines the main Project phases. There are five distinct phases, which are summarized in the table below. SDG&E will manage, own, and operate all system assets throughout the Project in agreement with UCSD. Stakeholder engagement will take place throughout all Project phases.

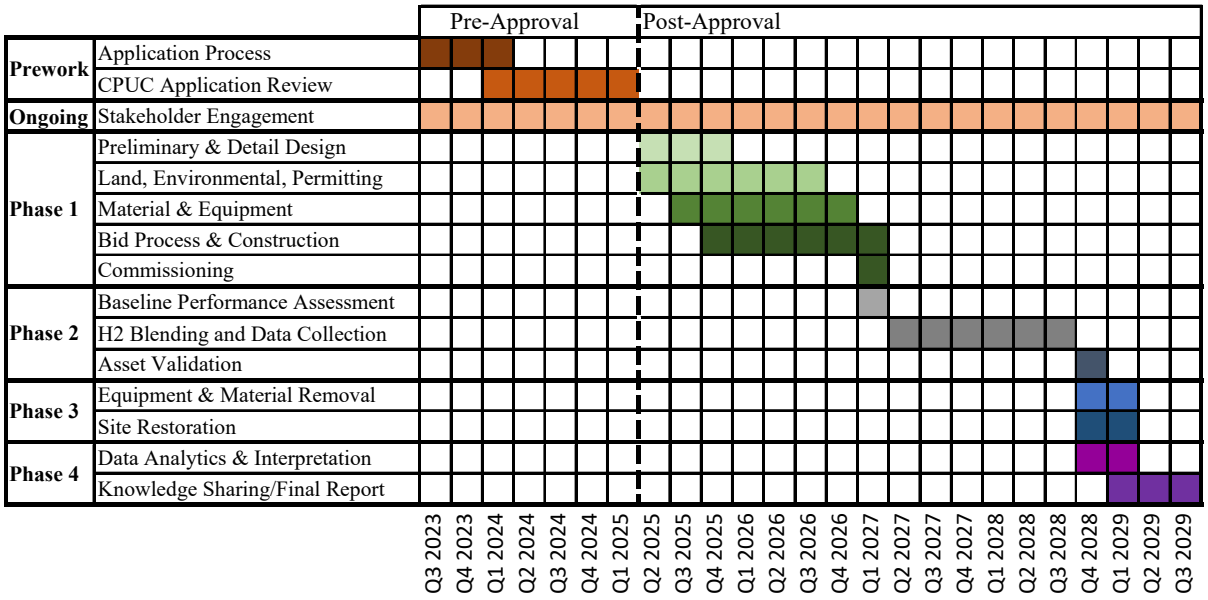
Table 1: Summary of Project Phases*

PHASE & ACTIVITY	DESCRIPTION	ESTIMATED DURATION
0. Pre-development	All efforts supporting this application submittal are considered "Pre-development." Upon California Public Utilities Commission (Commission) approval, the Project will move on to subsequent phases.	Pre-application submittal
1. Planning, Design, Construction and Commissioning	Hydrogen production and blending equipment are procured; the system is designed, constructed, permitted, and commissioned on UCSD property; PE pipes and meters are installed; inspections and any necessary remediation are conducted.	24 months
2. Testing and Demonstration	Hydrogen is blended into the system on a testing schedule; data is collected; equipment and pipelines are periodically inspected; and samples of pipelines and components are collected.	24 months (18 months live blending, + 6 months baseline assessment & validation)
3. Decommissioning, Equipment Removal, and System Restoration	Hydrogen equipment is removed from UCSD property, and the site is restored.	Five months
4. Knowledge Sharing	Data from the pilot is interpreted and disseminated; a public report will be released.	Nine months

*Project Phases overlap. *See* Estimated Project Schedule for Details.

Table 2 provides an estimated Project timeline.

Table 2: Estimated Project Schedule



1. Project by Phase Details

a. PHASE ZERO: Predevelopment and Site Selection

All efforts supporting this application submittal are considered "Pre-development." Upon Commission approval, the Project will move on to subsequent phases.

To develop this application, SDG&E collaborated with UCSD Facilities personnel to identify sites on UCSD's property that meet the following criteria:

- Ability to isolate from the main network;
- Constructability (adequate space);
- Avoidance of campus housing facilities due to stakeholder concerns;
- Safety; and
- Adequate space to site proposed pipe test loop and related equipment.

b. PHASE ONE: Planning, Design, Construction, and Commissioning

Phase One of the Project includes the detailed design, procurement, construction, and commissioning.

i. Planning

SDG&E will follow standard guidelines for new gas service, including evaluating load profile, load study, service sizing, and other technical needs.[9] SDG&E will document the evaluation of initial blending feasibility and perform a safety assessment supporting blending percentages.

SDG&E will incorporate the following considerations:

- Flow rates and directional consistency of receiving pipeline(s), including daily and seasonal variations.
- Current and expected future composition of natural gas in the pipeline system to determine interchangeability on customers' end-use equipment and the pipeline system's future capability to accommodate supplies.
- Maximum time and distance required for complete mixing to occur under all pipeline flow conditions.
- The design, operation, and overall condition of the receiving pipeline(s), including any sensitivities to gas constituents.
- Additional monitoring, control, and/or mixing equipment which may be required to verify adequate blending in the receiving pipeline system.

ii. Design, Construction, and Commissioning

The Project design will be finalized with a third-party expert as required (*See* Sec IV (12)). This third-party expert will be involved in every step of the process to ensure that testing protocols can be followed and are incorporated thoughtfully into the design.

The site will be prepared during the construction period, and equipment will be installed. Upon approval of this application, UCSD and SDG&E will develop contract terms and conditions that will outline the allowable construction criteria, area impacts, and other relevant details.

SDG&E will work with its vendors to develop and carry out commissioning activities and ensure the equipment and systems are in good working order.

[9] SDG&E, *Building Services Resource Center, Electric & Gas Service Step-by-Step Guide* (2021), *available at:* https://www.sdge.com/sites/default/files/gasload.xls.

iii. Equipment Selection and Procurement

All purchased equipment will be treated as an Operations and Maintenance (O&M) expense because it will be solely utilized to support this short-term research, development, and demonstration Project. SDG&E will manage, own, and operate the entire system throughout the project.

PE is the preferred material for the future of the state's natural gas distribution systems, and the system is in the process of fully transitioning to modern PE under the Commission's Gas Distribution Integrity Management Program (DIMP). Therefore, it is essential to test the effects of hydrogen on this material. Small-scale lab studies have indicated that the issues associated with blending hydrogen up to 20 percent in a PE distribution system pipeline are well-defined and understood.[10] The material is "capable of handling this blend."[11] Research to date indicates that hydrogen does not degrade PE pipes.[12,13,14] The SDG&E data collected in this Project will help determine if these lab studies may be validated with a large-scale, real-world deployment. Meters use sensitive baffles to measure fluid flow. There is a concern that older meter baffles might not be sensitive enough to detect and respond to hydrogen molecules. This Project will include experiments to understand the efficacy of existing meters versus new ones in accurately measuring hydrogen-blended gas.

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[10] U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration, *Gas Distribution Integrity Management Program (DIMP)* (August 23, 2018), *available at:* https://www.phmsa.dot.gov/pipeline/gas-distribution-integrity-management/gas-distribution-integrity-management-program-dimp.

[11] Pipeline Research Council International (PRCI): "Emerging Fuels – Hydrogen SOTA, Gap Analysis, Future Project Roadmap." Catalog No. PR-720-20603-R01. November 9, 2020. Page 45.

[12] COAG Energy Council, Hydrogen in the Gas Distribution Networks: A kickstart Project as an input into the development of a National Hydrogen Strategy for Australia(January 11, 2019), available at: http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/nhshydrogen-in-the-gas-distribution-networks-report-2019_0.pdf.

[13] International Gas Union Research Conference Rio 2017*, Using the Natural Gas Network for Transporting Hydrogen – Ten Years of Experience* (2017), *available at:* https://dgc.dk/media/v3hjik0j/c1703_igrc2017_iskov.pdf.

[14] National Renewable Energy Laboratory, *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues* (March 2013), *available at:* https://www.nrel.gov/docs/fy13osti/51995.pdf.

Table 3: Major Equipment List

Equipment	Description
PE Pipe from gas main to blending skid	Approximately 300 feet of new, state-of-the-art PE pipe will connect an existing SDG&E distribution pipe to the blending skid.
PE Pipe for the test loop	Approximately 200 feet of new, state-of-the-art PE pipe will be used to test hydrogen blends. At least two different types of resin representative of the PE in SDG&E's distribution system will be included in the test loop.
New Meters	One main gas meter will be installed to measure gas flow to the fuel cell.
Electrolyzer	Hydrogen in this study will be produced on-site via a dedicated, grid-connected electrolyzer. Additional equipment and instrumentation associated with the electrolyzer include the Supervisory Control and Data Acquisition (SCADA), chiller, and water de-ionizer.
Hydrogen Blending Skid	A hydrogen blending skid is required to blend natural gas with hydrogen.
Storage Tank	A pressure vessel that can store up to 11 kg of hydrogen at 435 pounds per square inch (psi) will be used to store hydrogen produced onsite. Per NFPA-2 code, this sized vessel is considered a non-bulk hydrogen storage container.[15]
Fuel Cell	The fuel cell will receive the blended gas and is considered "end-use equipment." The fuel cell produces combustion-free electricity that will be supplied to the SDG&E grid. The estimated maximum power output of the fuel cell will be 100 kilowatts. San Diego's Air Pollution Control District (APCD) does not require air permits for fuel cell distributed generator systems that meet the California Air Resources Board (CARB) criteria for certification due to minimal criteria pollutant emissions.[16]
Additional equipment	Additional equipment may include pressure regulators, temperature transmitters, gas analyzers, gas detectors/leak detectors, fire detectors,

[15] Hydrogen Technologies Code, NFPA2, National Fire Protection Association.

[16] 17 CCR §§ 94200-94214, *available at*: https://ww2.arb.ca.gov/sites/default/files/2022-05/dg06-final-regulation-unofficial_0.pdf.

Equipment	Description
	control valves, relief valves, isolation valves, and pressure and temperature transmitters.

c. PHASE TWO: Testing and Demonstration

Phase Two will focus on testing and demonstrating hydrogen blending from five percent to 20 percent blend by volume. Phase Two will be broken into three subphases: 1) baseline performance assessment, 2) live hydrogen blending, data collection, and analysis once the test is complete, and 3) performance validation.

i. Baseline Performance Assessment

SDG&E will perform a baseline assessment of the newly installed Project. The assessment will align with current inspection practices for natural gas pipeline installation. Baseline performance analysis will also include detailed inspection and surveys of the pipeline, fittings, valves, and meters. Leak surveys will also be conducted before the demonstration and continue throughout the Project. The Project test period will begin by establishing a 100 percent natural gas baseline in the new pipeline loop. In this way, SDG&E will benchmark PE pipe performance to compare and characterize any potential future degradation resulting from hydrogen blending.

ii. Live Hydrogen Blending Data Collection

SDG&E will collect data as it blends hydrogen into natural gas. The Project will allow for operational review and confirmation of the following within the limitations of the candidate Project site:

- Odorant compatibility;
- Leak detection equipment compatibility;
- Material compatibility;
- Component (*e.g.*, fittings, valves) compatibility;
- Long-term integrity modeling;
- Blend consistency (hydrogen blending injection skid);
- End-use appliance/equipment efficiency;
- Development of new Gas Standards for the construction, maintenance, and operations of hydrogen-blended natural gas systems;

- Effects on metering equipment; and
- Impact on emissions associated with hydrogen blending, including NO_x.

iii. Project Data Collection Plan

Table 4 provides an overview of the type of data SDG&E will collect with the Project. Each data element serves to validate past hydrogen blending research. Data and materials will be gathered before, during, and after blending is complete. The data will be analyzed to provide insights to confirm the hydrogen blending computability of the gas system and end-use equipment.

Table 4: Preliminary Project Data Collection Plan

Area	Objective	Frequency	Pre-Demo	During Demo	Post-Demo
Odorant sampling	Confirm that hydrogen does not affect the efficacy of the current natural gas odorant.	Monthly	✓	✓	
Leak surveys	Perform safety checks; repair any leaks before starting the demo; determine if hydrogen blends affect leakage from fittings, valves, etc.	Monthly and as needed for customer service calls	✓	✓	✓
Leak survey equipment	Validate the performance of new leak survey equipment.	Monthly and as needed for customer service calls		✓	
Samples of pipe/pipeline components (Material Compatibility)	Verify if there are any material impacts (polyethylene piping, elastomers, rubbers, valves, fittings) after	Before demo and post-demo	✓		✓

Area	Objective	Frequency	Pre-Demo	During Demo	Post-Demo
	exposure to hydrogen blends.				
Customer meters	Compare data from meters and blending skid data to confirm the accuracy of meters.	Monthly		✓	✓
End-use equipment evaluation	Ensure equipment is working correctly; validate gas interchangeability calculations and lab testing that has been done.	Monthly and as needed for end-use equipment	✓	✓	✓
End-use equipment checks for emissions, including NO_x	Measure emissions from the fuel cell.	To be determined	✓	✓	

Table 5 summarizes the incremental hydrogen blending level increase schedule during planned operations. The blending percentages align with D.22-12-057 and UC Riverside's Hydrogen Blending Impacts Study (UC Riverside Study) recommendations.[17] Per the study, "it is critical to conduct real-world demonstration of hydrogen blending under safe and controlled conditions. The recommended hydrogen percentages for this demonstration are five to 20 percent." Data collection will start with a target blend of five percent and gradually up to 20

[17] UCR, *Hydrogen Blending Impacts Study* (July 2022) at 4; *available at* https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF.

percent. Six months of data will be collected for the lower blends (up to 10 percent), and 12 months of data will be collected for the higher blends (10 to 20 percent).

Table 5: Estimated Blending Intervals by Increments

Percent Blending Level	Timeframe
Zero percent (100 percent natural gas)	Three months prior to demonstration
Five percent	Months one to three
Up to 10 percent	Months four to six
Up to 15 percent	Months seven to 12
Up to 20 percent	Months 13 to 18

iv. Post-Data Collection Activity

Asset validation includes the following post-hydrogen blending activities:

- Leak surveys of the pipeline system to verify that no leaks have developed.
- Gathering of pipe and component samples to test and compare with pre-demo samples to determine if there are any material changes after exposure to hydrogen blends.
- End-use equipment checks to ensure equipment continues to work correctly.
- The meter will be removed for mechanical integrity testing.

d. PHASE THREE: Decommissioning, Equipment Disposition, and System Restoration

Phase Three of the Project will commence after the Testing and Demonstration period. In Phase Three, SDG&E will decommission all Project equipment and work with UCSD to restore the site.

Upon conclusion of the Project, SDG&E will evaluate the best use for the hydrogen-related equipment, including appropriate disposition. Samples of pipe and components will be collected during this period for further analysis of the impacts of hydrogen on PE pipe. SDG&E will also work with UCSD to restore the Project site per the terms and conditions to be developed with UCSD.

e. PHASE FOUR: Data Analysis and Dissemination

Following the completion of the Project, SDG&E will draft its final Annual Report, which will include technical findings from the Project. The Annual Report will be available on

the SDG&E website and served on the service list. This report will guide future hydrogen blending, supporting a hydrogen injection standard in the California gas system. SDG&E will collaborate with the other Joint Utilities and the Commission to determine the best next steps for disseminating the data collected through the Project. As California is widely understood to be a leader in national energy policy, SDG&E anticipates significant and broad interest in the results of this pilot.

2. Candidate Location Site Map and Project Plot Plan

Figure 1: Proposed Blending Demonstration Site on UCSD Property

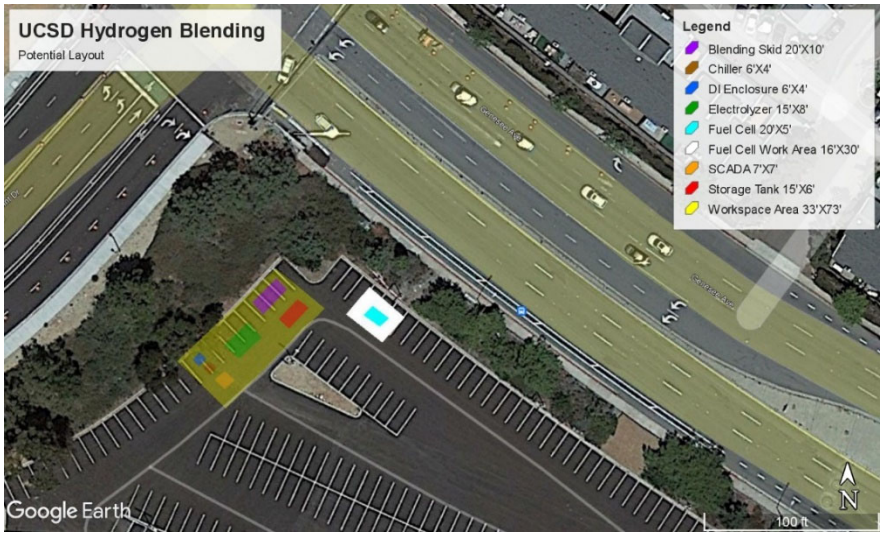
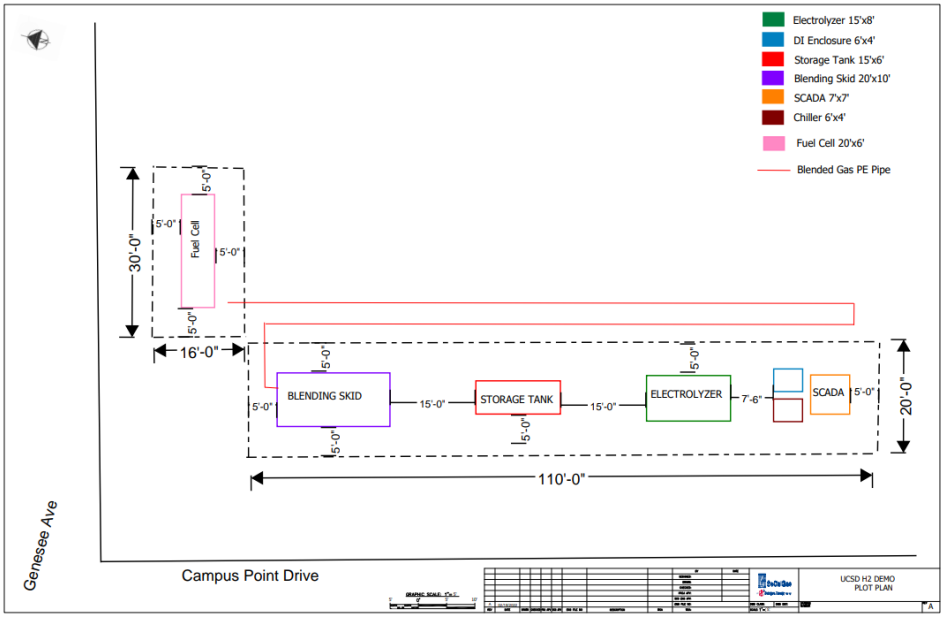


Figure 2: Preliminary Project Plot Plan



III. PROJECT GUIDANCE

A. API RP 1173 Pipeline Safety Management System

Safety is at the core of this Application. The Project utilizes the American Petroleum Institute's (API) 1173 Pipeline Safety Management System (PSMS) Plan-Do-Check-Act model.[18] SDG&E is currently in the "Plan" stage. The Project will move into the "Do" stage by initiating the controlled blending Project that the Plan stage has informed. Leading up to and during the "Do" stage, SDG&E will establish project management plans and procedures, train staff on hydrogen blends and Project equipment, document, and record data from the demonstration, and engage with stakeholders, including the communities and end users. The Project leads into the "Check" phase, where SDG&E will learn from the data collected, including utilizing the data for an integrity/risk management analysis. Should these pilots lead to a hydrogen injection standard, the "Act" phase would follow. In collaboration with the Commission and the Joint Utilities, SDG&E would translate the knowledge gained from the Joint IOU projects and other relevant studies into safety policies and operating procedures that would allow for safe hydrogen blending in the common natural gas system. Plan-Do-Check-Act is a continuous learning framework that SDG&E will follow for all hydrogen blending activities.

B. Overarching Safety Case

SDG&E's safety efforts to be taken before, during, and after the Project include, but are not limited to:

- Hydrogen Safety Training for SDG&E personnel, relevant USCD personnel, and relevant first responders;
- Safety Assessment for hydrogen storage;
- Conduct pre-, during, and post-implementation leak surveys;
- Create hydrogen blending specific customer protocols and emergency response plans;
- Test existing and new leak survey equipment;
- Test emissions from the fuel cell flue system; and

[18] Pipeline SMS, *RP 1173*, *available at:* https://pipelinesms.org/rp-1173/.

- Conduct equipment inspections during commissioning, testing, and prior to decommissioning.

The hydrogen system will include continuous remote monitoring that will notify SDG&E of leakage events. Safety protocols and remote controls will stop hydrogen production and automatically shut down Project operations should leakage be detected above a defined level.

C. Stakeholder Engagement

SDG&E recognizes the importance of stakeholder and community engagement around novel hydrogen projects such as blending. SDG&E has engaged and coordinated with various stakeholders connected to the proposed Project, including the Commission's Energy Division, UCSD staff, faculty, students, and environmental advocates. In particular, SDG&E has re-designed the scope of the Project since filing A.22-09-006 on September 8, 2022 with the Commission. Initially, the SDG&E Project was to blend hydrogen with natural gas at a student residence hall to fuel end-use appliances, including campus-owned water heaters. This was a safe and rigorous testing design and approach. However, upon hearing stakeholder concerns with this project design, SDG&E and UCSD staff worked together to develop a project that avoids blending in campus buildings. This example of meaningfully addressing and responding to stakeholder concerns represents SDG&E's overall approach.

A summary of notable stakeholder engagement to date is listed here:

- August 19, 2022: Memorandum of Understanding (MOU) executed between UCSD and SDG&E.
- September 9, 2022: SDG&E delivered an on-site presentation to UCSD Graduate and Family Housing Advisory Committee (GFHAC) and students.
- December 5, 2022: SDG&E participated in a UCSD Student Town Hall and presented highlights of the proposed Project.
- December 2, 2022: SDG&E and the UCSD Fire Marshall and Facilities Management performed a walkthrough of the Voight site.
- June 13, 2023: SDG&E and the Joint Utilities held a public Joint Utilities Stakeholder Workshop to present their proposed Projects.
- November 6, 2023: SDG&E and the Joint Utilities held a public Joint Utilities Technical Workshop to solicit feedback on technical aspects of the proposed Projects, including hydrogen leakage, emissions, and material safety.

- November 7, 2023: SDG&E participated in a UCSD Student Town Hall and presented highlights of the updated proposed Project.
- November 14, 2023: SDG&E and select UCSD academic faculty and staff met to explore academic collaboration opportunities around the blending project.
- February 20, 2024: UCSD and SDG&E signed an Amended and Restated MOU reflecting the new Project scope.

In addition to UCSD serving as a site host, the partnership with UCSD creates an opportunity for SDG&E and UCSD staff and students to collaborate on research projects related to hydrogen blending and associated equipment. In particular, the candidate Project site sits around the corner from the UCSD Center for Energy Research (CER), where scientists, faculty from multiple UCSD departments, visiting scholars, and students perform basic and applied research in solar energy, fuel cells, energy storage, and related disciplines. SDG&E will continue to nurture this partnership throughout the Project, support educational collaboration, and provide students with professional development opportunities.

The SDG&E Project team will coordinate with the SDG&E Office of the Customer to identify relevant community-based organizations (CBOs) for engagement. SDG&E proposes a maximum of four CBO engagement workshops during Phase One and an additional three workshops, one each at the conclusion of Project Phases Two, Three, and Four, to share updates, conclusions, and findings.[19]

Currently, SDG&E partners with CBOs for outreach and education for other programs, including fire safety, clean transportation, and energy efficiency. These CBOs are compensated through an annual MOU that outlines their compensation rates, similar to a grant. CBO compensation ranges depending on the resources and time a CBO can dedicate to a project.

Details related to the Project will be available online, including related environmental health and safety issues. The demonstration site will include signage directing viewers to the website and the SDG&E hydrogen email address for additional information: hydrogen@sdge.com.

[19] D.22-12-057 at 65 (Conclusions of Law 30).

IV. D.22-12-057 ORDERING PARAGRAPH 7 COMPLIANCE

Decision 22-12-057 contains several Ordering Paragraphs (OP) that outline requirements for the hydrogen blending pilot projects. The Joint Utilities engaged with the Energy Division throughout the development of this application to ensure that the orders were carefully understood and followed. Below is a detailed discussion of how the SDG&E Project complies with OP 7, which directs the Joint Utilities to propose pilot programs to test hydrogen blending in natural gas.

OP 7.a.

> "Ensures long-term safety of the California Pipeline, the prevention of hydrogen leakage, the inclusion of hydrogen monitoring, the consideration of the dilution rate, and the monitoring and reporting of all mechanical characteristics of hydrogen blends in the natural gas pipeline stream."

The SDG&E Project will help prepare California to develop a hydrogen injection standard that ensures the long-term safety of the California Pipeline, prevents hydrogen leakage, and understands the impacts of mechanical characteristics of hydrogen blends.

Specifically, the Project will test the material impacts of hydrogen blending on approximately 200 feet of state-of-the-art PE pipe in a closed-loop, standalone, and custom-built distribution pipe test loop. This Project will be entirely disconnected from SDG&E's existing natural gas system, *e.g.*, "closed loop."

Because the pipe loop length is approximately 200 feet, and the system is a closed loop, terminating into a single fuel cell, SDG&E has not included dilution rate considerations as they are not relevant to this design. Dilution rates are addressed in Technical Chapter 2, SoCalGas Open Blending Project.

The Project includes several measures to ensure safe operation, prevent hydrogen leakage, and monitor gas characteristics.

SDG&E will:

- Perform enhanced leak detection protocols throughout the Project to ensure that the gas system and associated end-use equipment are not compromised.
- Perform leak detection surveys to ensure potential leaks are caught early and reported.

- Deploy robust monitoring surrounding the hydrogen production, storage, and blending areas to detect any potential leak from hydrogen equipment.
- Include a gas chromatograph at the outlet of the blending skid to ensure the accuracy of the blend percentage.
- Include continuous remote monitoring that will notify SDG&E of leakage events.
- Include remote controls will stop hydrogen production and automatically shut down hydrogen production should leakage be detected above a defined level.

OP 7.b.

"Prevents hydrogen from reaching natural gas storage areas and electrical switching equipment directly or through leakage."

The Project features a new, custom-built distribution pipe test loop that is completely isolated from the rest of the gas distribution system, natural gas storage areas, and electrical switching equipment. There is no possibility of hydrogen reaching these items. The Project will utilize gas flow preventers and shut-off valves to prevent hydrogen from reaching electrical equipment or natural gas networks.

OP 7.c.

"Avoids end user appliance malfunctions."

The end-use appliance in this Project is a new fuel cell that will be installed for this test. The fuel cell will be manufacturer approved to accept at least twenty percent hydrogen by volume. The fuel cell manufacturer will be involved in installing, commissioning, maintaining, monitoring, and decommissioning the equipment.

OP 7.d.

"Evaluates hydrogen injection at blends between [0.1] and five percent and five percent to twenty percent; such evaluations must adhere to approved monitoring, reporting, heating value, system safety, environmental considerations, end-use emissions, and all other elements enumerated in this decision."

The SDG&E Project will evaluate blends between five and twenty percent by volume. It will adhere to approved monitoring, reporting, system safety, environmental considerations, and

end-use emissions requirements in alignment with the study published by UC Riverside.[20] The "open system" test of [0.1] and five percent is addressed by SoCalGas in Chapter 2 of this Application.

OP 7.e.

"Specifies the amount of funding necessary to complete all aspects of the proposal and proposes testing durations adequate to draw meaningful conclusions."

A Class Five cost estimate was performed to calculate the funding necessary for Phases One through Four. Section V summarizes the cost of the Project. Refer to Workpaper Three (WP-3) for the detailed breakdown of Project cost.

Regarding the duration of the Project, it was designed to be reasonable and aligned with other notable hydrogen blending studies, including the HyDeploy Keele Study and the UCR Study. Our study will evaluate the impact of hydrogen blends over 18 months. Similar studies were able to gather enough data and evidence for meaningful conclusions through this time frame, including the first Phase of the HyDeploy Keele University Project, which was conducted on campus over eighteen months.[21,22] Laboratory testing has been conducted in increments of ten to 30 days for a fixed blend percentage.[23,24] The Project will test at least three months each for lower levels (five and 10 percent) and six months each for greater hydrogen concentrations (15 and 20 percent). Considering this is a closed system test on PE pipe, this time range can provide data and evidence to support the future development of hydrogen blending standards.

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[20] CPUC, *Hydrogen Blending Impacts Study* (July 2022) at 4; *available at:* https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF.

[21] U.S. Department of Energy – Office of Scientific and Technical Information, Polymer pipes for distributing mixtures of hydrogen and natural gas. Evolution of their transport and mechanical properties after an ageing under an hydrogen environment(2010), available at: https://www.osti.gov/etdeweb/servlets/purl/21400887.

[22] Netbeheer Nederland, *Management Summary – Hydrogen blending with Natural Gas on Ameland (*April 2012), *available at:* https://www.netbeheernederland.nl/_upload/Files/Waterstof_56_7c0ff368de.pdf.

[23] PE 100+ Association, *Permeation Studies On Polyethylene Pipes at Different Temperatures* (GUT 6789/22) (August 29, 2022), *available at:* https://www.pe100plus.com/Download/News/PieceJointeInfo/fichier/508.pdf.

[24] Miroslav Penchev, Taehoon Lim, Michael Todd, Oren Lever, Ernest Lever, Suveen Mathaudhu, Alfredo Martinez-Morales, and Arun S.K. Raju*. 2022. Hydrogen Blending Impacts Study Final Report. Agreement Number: 19NS1662.

OP 7.f.

"Is consistent with all directed courses of action specified in this decision relevant to leakage, reporting, heating value, system safety, environmental considerations, end-use emissions, and all other elements enumerated in this decision."

The Project is consistent with all directed courses of action specified in decision D.22.12-057. The details of how the Project addresses all courses of action are summarized in Table 6 below.

Table 6: Directed Courses of Action in D.22-12-057

Topic	Recap of SDG&E's Action	Reference
Leakage	The Project will be designed to minimize and monitor leakage for hydrogen, methane, and methane blend with sensors, remote alerts, and other detection systems.	Section II and Exhibit 3A – Preliminary Testing Protocols
Reporting	The Project's testing program will collect and analyze data as described in Section II. SDG&E will work with a third party and the Joint Utilities to report on findings.	Section II
Heating value	There is no heating value impact on a customer, given that the fuel cell will export power back to the SDG&E grid.	Section IV
System Safety	Various safety and alert systems are in place to ensure the Project adheres to safety requirements, including a remote monitoring, alarm, and shutdown system. Continuous remote monitoring that will notify SDG&E of leakage events. All relevant codes and standards will be followed.	Sections II, III and IV
Environmental considerations	The SDG&E project will use water and grid electricity offset by RECs to produce clean hydrogen. SDG&E will strive to use these resources responsibly. No local air permits will be required for distributed generation technologies.	Section II and Section III
End-use emissions	NOx, CO2, CO, and Oxygen will be measured from the fuel cell system to	Section III.B, Exhibit 3A

Topic	Recap of SDG&E's Action	Reference
	monitor the emission performance. While SDG&E does not anticipate NOx issues, NOx monitoring and testing will nevertheless be conducted.	
Blending limitations	The Project will evaluate hydrogen blending between five percent to twenty percent by volume on a closed system as directed by the D.22-12-057 and suggested by the UCR study. The closed system is a test loop using representative SDG&E gas distribution pipeline components.	Sections II and IV
Additional consideration	Section IV addresses how the Project is complying with the directives of decision D.22.-12-057	Section IV

OP 7.g.

"Proposes rigorous testing protocols consistent with the UC Riverside Study."

The Project is consistent with all directed courses of action specified in the Hydrogen Blending Impact Study (UC Riverside Study) and actions identified in decision D.22-12-057.[25] In addition, the Joint Utilities sought feedback on their data collection plans from stakeholders, the public, and leading national hydrogen blending experts in the technical stakeholder workshop held on November 6, 2023. The Joint Utilities incorporated feedback from this technical workshop into their preliminary testing and data collection plans.

Rigorous testing protocols will be developed to address leakage rates, degradation, durability, and hydrogen embrittlement on materials, fittings, and other components. Exhibit 3A demonstrates the pre-design test plan SDG&E has developed for the Project.

OP 7.h.

"Takes into account parties' comments and further stakeholder input and includes the opportunity for compensation for parties and for community-based organizations."

[25] CPUC, *Hydrogen Blending Impacts Study* (July 2022) at 4; *available at* https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF.

SDG&E has and will continue to consider parties' comments and stakeholder input. Refer to Section III.C for more details on SDGE's stakeholder engagement activities, plans for engagement post-application filing, and CBO compensation.

OP 7.i.

> "Propose a methodology for performing a Hydrogen Blending System Impact Analysis that can ensure that any hydrogen blend will not pose a risk to the common carrier pipeline system."

This System Impact Analysis would be a checklist for Joint Utilities and potential third parties connecting to the gas system to ensure the standard carrier pipeline system remains safe should a hydrogen injection standard be established.

The Joint Utilities propose developing a methodology for performing the Hydrogen Blending System Impact Analysis upon completion of the projects. The proposed methodology will provide a framework to ensure hydrogen blends do not compromise gas system integrity and safety or impact end-use equipment.

The methodology will benefit from using the data collected from the demonstration Projects. The proposed methodology for hydrogen blending will follow a framework similar to that of a biomethane interconnection agreement.

The framework will include, but will not be limited to:

- Identification of downstream systems.
- Potential materials.
- Operating pressures.
- Equipment (*e.g.*, valves, meters, etc.).
- Review the pipeline history and end-use equipment.
- Any further analysis that is deemed necessary by the interconnecting utility.

OP 7.j.

> "Includes new or revised heating values and discuss whether heating values would be modified through propane or other means and whether such modification to heating value can be done safely."

The SDG&E Project will assess and measure the heating value of blended hydrogen and natural gas for learning purposes. However, since SDG&E is the only offtaker for the blended

gas, any change in heating value will not impact customers. Therefore, SDG&E does not plan to create a new thermal zone. Additionally, SDG&E will not modify the heating value with propane or other means.

OP 7.k.

> "Demonstrates the ability to reliably detect leakage of any hydrogen, methane, or hydrogen/methane blends and describes rigorous hydrogen leak testing protocols that are consistent with leak testing and reporting elements identified in the University of California at Riverside's 2022 Hydrogen Blending Impacts Study, identifies and addresses the comments presented by parties in this proceeding regarding leak issues, and identifies and addresses the comments presented by workshop stakeholders in this proceeding regarding leak issues."

This Project will include procedures to monitor, identify, and quickly repair leaks to minimize safety risks, including appropriate methods for prompt and reliable leak detection, including using odorant. First, the Project will utilize the appropriate design and construction standards and operating gas standards within the design parameters to minimize the risk of hydrogen leakage. Additionally, leaks will be monitored at the system level with pressure sensors, at the facility level with hydrogen sensors, or through audible or ultrasonic detection. Operators will also manually inspect for leaks on a monthly basis with handheld hydrogen detectors or soap bubble leak detection. Sampling will be conducted throughout the process to evaluate odorant compatibility and confirm the effectiveness of the odorant.[26]

Instrumentation systems will measure the blended gas's overall performance, temperature, pressure, and quality. Moreover, the fuel cell system has a monitoring/control system for performance control.

OP 7.l.

> "Contains an independent research plan for assessment, measurements, monitoring, and reporting through an independent party, which must be engaged in such activities during the development, construction, operational life, and decommissioning of the pilot project."

[26] Haeseldonckx, D., and W. D'haeseleer. 2007. "The Use of the Natural-Gas Pipeline Infrastructure for Hydrogen Transport in a Changing Market Structure." International Journal of Hydrogen Energy 32, nos. 10-11 (July): 1381–1386. ISSN: 03603199. doi:10.1016/j.ijhydene.2006.10.018.

Upon approval of this application, the Joint Utilities will issue a request for proposal (RFP) to solicit competitive bids for an independent party (or parties) to complete the independent research plan covering the phases of the Project, including development, construction, operations, and decommissioning. Given the differences in demonstration projects, different entities might be contracted for various aspects of the research plan. All information related to the SDG&E pilot herein should be considered pre-development. *See* Amended Application for more details on this approach.

V. COST ESTIMATES

An Unloaded Direct Cost estimate is provided in Table 7. The unloaded direct cost includes all anticipated expenses, with contingency, for the entirety of the Project. The Project costs are based on a Class 5 estimate and shown in 2023 dollars. Please see WP-3 for the detailed breakdown of Project cost estimates by phase. Details on loaded direct costs and revenue requirements are described in Chapter 7, Prepared Direct Testimony of Eric Dalton, Jack Guidi, and Marjorie Schmidt-Pines.

Table 7: Project Cost Estimates, in US Dollars

Total Direct Capital and O&M (Direct Costs, 2023 Dollars) (In Millions)

	2025	2026	2027	2028	2029	Total
Capital	0.0	0.0	0.0	0.0	0.0	0.0
O&M	7.2	6.4	0.6	1.8	0.1	16.1
Total	7.2	6.4	0.6	1.8	0.1	16.1

Additionally, SDG&E will evaluate relevant federal tax credits that could be used to reduce the cost of this project to ratepayers and if appropriate may apply for those should the Project qualify under IRS guidance. Further details for accounting and cost recovery can be found in Chapter 7.

VI. CONCLUSION

The SDG&E proposed Project is designed to study the impact of hydrogen blended natural gas (up to 20 percent) in materials and infrastructure common to plastic natural gas distribution gas systems. The goal of the Project is to help inform a future safe hydrogen injection and blending standard for California. As a clean energy leader, California is vital in validating safe and effective decarbonization methods, including hydrogen blending in existing

natural gas systems. SDG&E looks forward to partnering with UCSD and the Joint Utilities to investigate live hydrogen injection, which could play a key role in enabling California to achieve its decarbonization goals.

For all the reasons discussed above, SDG&E requests that the Commission authorize SDG&E to implement the Project and to establish the proposed cost recovery mechanisms. Specifically, SDG&E requests that the Commission approve the following:

1. Authorize SDG&E to establish and implement its proposed Project, including entering into the necessary contracts and/or agreements with third parties to implement the Project;
2. Authorize SDG&E to recover all costs related to the Projects as set forth above and in Chapter 7;
3. Authorize SDG&E to create two-way balancing account (*i.e.*, the Hydrogen Blending Demonstration Project Balancing Account "HBDPBA") to track and recover the estimated costs to implement the Project;
4. Authorize SDG&E to create a subaccount on the HBDPBA to record its proportional share of the cost allocation for any shared plans, studies and reporting required by D.22-12-057; and
5. Granting of such other relief as is necessary and proper.

This concludes my prepared direct testimony.

VII. WITNESS QUALIFICATIONS OF POOYAN KABIR, PhD

My name is Pooyan Kabir. I am the Principal Engineer for hydrogen at SDG&E. I have been with SDG&E since August 2021. Before joining SDG&E, I was an Engineer at McDermott International, a multinational Engineering Procurement Construction company, where I worked on storage vessels for different mediums, including hydrogen, LNG, and water.

I hold a Bachelor of Science in Structural Engineering from the University of Tehran, a Master of Science in Materials from Texas A&M University, and a Doctorate in Structural Mechanics from the University of Illinois at Urbana-Champaign.

I have not previously testified before the Commission.

Exhibit 3A: Preliminary Testing Protocols – H2 Blending Demonstration Project

Joint IOU Hydrogen Blending Demonstration Application

Prepared by: San Diego Gas & Electric Company

This document creates a preliminary test protocol for the proposed SDGE Hydrogen Blending Demonstration Project in the distribution system. The distribution system is defined as pipelines and components with operating pressures of 60 pounds per square inch gauge (psig) or less.

The proposed SDGE Hydrogen Blending Demonstration Project will be in an isolated portion of the natural gas distribution system located at UC San Diego property for blending hydrogen from five percent to twenty percent by volume. This document presents our strategy for gathering data on four distinct topics aimed at validating knowledge derived from research studies. The four topics encompass: leakage, material testing, heating value measurement, and end-use emissions. The preliminary test protocol for each topic is discussed below. A more detailed test protocol will be developed at Phase 1 of the project.

1. Leakage
   a) Odorization

   For the demonstration project, hydrogen-natural gas blends will be odorized per Company Odorization Gas Standard. Odorant levels will be monitored upstream of the hydrogen injection point as a baseline and multiple locations downstream of the hydrogen injection point to verify odorant intensity throughout the pipelines. Four consecutive weekly odor intensity tests will be conducted, followed by monthly tests, which will confirm hydrogen compatibility and efficacy of the odorant.

   b) Leak Survey

   Leak survey will be conducted at frequencies listed in Table. Only Company Field Employees qualified through Gas Operations Training may perform the leak survey. Pipe joints, valves and meters will be leak surveyed. Downstream of the meter, pipe connections to the end use appliance will be leak surveyed as well to confirm safety, integrity, and reliability. SDG&E will explore various leak survey technologies available on the market.

Table 1. Preliminary Leak Survey Technologies and Frequency

Demo Project	Examples of Leak Survey Technologies to Explore	Leak Survey Frequency
Closed System	Portable gas detectors Fiber optic technology Ground vehicle Mass balance method	Pipeline: monthly Pipe connections to the fuel cell

2. Materials Testing

SDG&E plans to test pipe performance testing at the end of each blending interval, five, ten, fifteen and twenty percent volume of hydrogen. In addition to that, a set of control samples will be collected for pipe performance testing. The control set has gone through only natural gas blend for the same duration under similar flow conditions. Pipe performance at initial stage of the project will be measured to benchmark the characteristics of the pipe. At least two types of PE pipe will be included in the project and tested.

In addition, the effect of hydrogen on materials will be continuously monitored through leak surveys at various points within the system. If any leaks are detected during leak surveys, the affected section of the pipeline or specific components may be isolated for further material testing to assess any potential impact of hydrogen on the material's integrity.

3. Heating Value Measurement

The current gas chromatographs used for heating value measurement have a limitation to detect hydrogen. To ensure accurate gas composition measurement, it is essential to implement and incorporate compatible gas chromatographs. For the UCSD project, SDG&E will monitor the caloric value of the blend both at the blending injection skid and at the meter set assembly of the Fuel Cell.

4. End Use Emissions

SDG&E will perform emissions testing (CO_2, NO_x, CO, and O_2) per San Diego Air Quality Management District (SDCAPCD) test methods to determine the end use performance and combustion efficiency. Table 2 summarizes end-use equipment preliminary proposed testing protocol.

Table 2. Preliminary End- Use Equipment Proposed Testing

Demo Project	End Use Equipment	Emissions Testing		Visual Testing	Frequency
		Monitored Parameters	Applicable Test Methods		
Closed system	Fuel Cell	NOx, CO2, CO, O2	SDCAPCD Rules	N/A	Monthly

Exhibit 3B: Amended and Restated Memorandum of Understanding with UCSD (2024)

Joint IOU Hydrogen Blending Demonstration Application

Prepared by: San Diego Gas & Electric Company

AMENDED AND RESTATED MEMORANDUM OF UNDERSTANDING

By and Between

UNIVERSITY OF CALIFORNIA, SAN DIEGO ("UCSD")
and
SAN DIEGO GAS & ELECTRIC COMPANY ("SDG&E")

RECITALS

WHEREAS, UCSD and SDG&E are parties to that certain Memorandum of Understanding dated August 19, 2022 ("Original MOU");

WHEREAS, UCSD is an internationally recognized leading public research university;

WHEREAS, the UCSD properties are a "living laboratory" incubating numerous clean energy initiatives and technologies that contribute to future decarbonized energy systems;

WHEREAS, clean hydrogen is a promising carbon-free fuel that will be critical to supporting California's clean energy transition on the electric and natural gas systems;

WHEREAS, the California Public Utilities Commission ("CPUC") has asked investor-owned gas utilities including SDG&E to inform on a safe hydrogen injection and blending standard for California's natural gas pipeline system;

WHEREAS, SDG&E seeks to demonstrate safe hydrogen injection and blending in a polyethylene distribution system with gas-powered equipment before informing on a standard;

WHEREAS, after initial collaboration under the Original MOU, the program was materially re-scoped; and

WHEREAS, UCSD and SDG&E desire to amend and restate in its entirety the Original MOU as set forth herein.

NOW, THEREFORE, UCSD and SDG&E enter into this non-binding Amended and Restated Memorandum of Understanding ("MOU") effective as of February 6, 2024.

I. TERM

The term of the MOU commenced on August 19, 2022, the effective date of the Original MOU.

II. PURPOSE

UCSD and SDG&E enter into this non-binding MOU to collaborate on a proposed multi-year pilot demonstration program that seeks to understand the impacts of 5%-20% hydrogen blends in common components of the natural gas distribution pipeline system as more particularly described in Exhibit A attached hereto and incorporated herein by reference ("Project").

This proposed Project is part of a joint gas utility CPUC application to study the impacts of hydrogen on California's natural gas infrastructure. The Project requires and is dependent upon approval by the CPUC and is aligned with the goals and directives of CPUC Decision 22-12-057.

This non-binding MOU summarizes principal terms of a proposed collaboration to be set forth in a future, definitive joint demonstration agreement (the "Joint Demonstration Agreement").

III. LOCATION

The isolated, purpose-built pipeline portion of the system "test loop" and fuel cell to receive the blended gas will be in a location mutually agreed to by the parties on UCSD property prior to March 31, 2025. A candidate location that may meet these criteria is depicted in Exhibit A, Figure 2 as the parking lot southeast of Genesee Ave and Campus Point Drive ("Voight Parking Lot"), but is subject to change to another location on UCSD property. With slight modifications, the project design is suitable to be placed at alternative candidate sites. The location shall meet the following minimum criteria: (a) SDG&E design purposes; (b) reasonable proximity to existing SDG&E gas and electric grid tie-ins; and (c) reasonable alignment with SDG&E cost estimates.

IV. GENERAL CONSIDERATIONS

1. This MOU does not supersede other existing agreements and/or memorandums of understanding between the parties, except for the Original MOU.
2. Each party will retain its primary responsibility for meeting all legal and regulatory requirements pertaining to it and its property.
3. Participation in any phase of the MOU is voluntary. Nothing contained in this MOU shall obligate any party to continue participating in any phase of the MOU and any party may terminate its participation in any phase of the MOU at any time for any reason or no reason in accordance with Section IV(6) below.
4. This MOU is not a contract but merely a non-binding memorandum of the understanding of the parties to coordinate their efforts with respect to establishing

the basis for the proposed Project. Neither party shall be bound with respect to any of the matters set forth in this MOU. This MOU does not create a partnership, joint venture or relationship of trust or agency between SDG&E and UCSD. Neither party shall be authorized to act on behalf of the other party, or to make representations or commitments of any kind on behalf of the other party.

5. Amendments to this MOU may be made by notification of the proposed changes to the other party and will become effective upon execution by both parties, which may occur in counterparts.
6. This MOU may be terminated by delivering written notice to the other party, effective thirty (30) calendar days following the date of delivery of such written notification.
7. This MOU shall be included as an Exhibit in SDG&E's testimony to the CPUC.

V. THE PARTIES SHALL ENDEAVOR TO:

1. Collaborate to establish Project plan and terms and conditions, including construction, siting, deployment, and removal of associated equipment and utilities and reasonable timelines;
2. Collaborate to determine communications, education, safety, and fire safety protocols with UCSD staff, students, and others who may be affected by the Project; and
3. Seek to find research collaboration areas to support student and faculty research.

VI. SDG&E SHALL ENDEAVOR TO:

1. Construct an isolated test loop of state-of-the-art polyethylene pipe and potentially other representative pipeline materials that will accommodate blended hydrogen and natural gas and feed into a fuel cell as demonstrated on Exhibit A.
2. Ensure that the Project adheres to the applicable code level for noise;
3. Manage construction, procurement, and temporary siting on UCSD property of related hydrogen pilot equipment, including but not limited to an electrolyzer, fuel cell, blending skid, and a custom-built pipeline loop owned by SDG&E;
4. Test hydrogen injection and blending on the system in increments from 5% to 20% by volume over the course of the Project;
5. Remove certain Project equipment following the end of the Project;
6. Provide customer services and stakeholder engagement to support the UCSD community throughout the duration of the Project; and
7. Seek rate recovery for the Project from the CPUC.

VII. UCSD SHALL ENDEAVOR TO:

1. Provide easements (and/or temporary license) and site access sufficient to install, operate, maintain and remove the Project equipment;
2. Provide facility access to test end use equipment as necessary for both common areas and in-unit, within reason;
3. Provide access to test and verify system performance;
4. Assist with obtaining any necessary permits, as required and necessary for the Project; and

5. Encourage faculty and student engagement to further the achievement of Project goals, for example in the areas of environmental engineering, behavioral sciences, and environmental education, among others.

VIII. MISCELLANEOUS

This non-binding MOU is not a contract or an agreement for a contract, but an expression of the intention of the parties to negotiate toward a binding and definitive Joint Demonstration Agreement and such other transaction documents based on the understandings contained herein and such additional or different terms as may be mutually acceptable to the parties. Neither party shall have any obligation to commence or continue negotiations and may terminate negotiations at any time for any reason or no reason whatsoever. Neither of the parties shall be bound with respect to any of the matters set forth in this MOU, except to the extent such matters are contained in separate binding and definitive transaction documents executed by both parties. Any such definitive transaction documents will contain usual and customary provisions for transactions of the types contemplated therein with due regard for applicable tax, financial and regulatory requirements.

IN WITNESS WHEREOF, the parties hereto have executed this Amended and Restated Memorandum of Understanding as of the last date written below:

UNIVERSITY OF CALIFORNIA, SAN DIEGO

By Maureen Hannigan Date 2/20/2024

Title: Interim Vice Chancellor, Resource Management and Planning, UCSD

and

SAN DIEGO GAS & ELECTRIC COMPANY

By _____ Date 2/20/2024

Title: Chief Commercial Officer, Energy Innovation, SDG&E

EXHIBIT A – Description of Project

The purpose of the San Diego Gas & Electric Hydrogen Blending and Injection demonstration on UCSD property is to specifically provide operational, live blending data for blending up to 20% hydrogen gas by volume in an isolated portion of a polyethylene pipeline distribution medium pressure natural gas system. The Project will inform the feasibility of developing a state-wide hydrogen blending standard for polyethylene pipe gas distribution systems that serve existing customers and equipment in the State of California.

The Project will be sited in a location on UCSD property to be determined by the parties prior to March 31, 2025 to accommodate ongoing UCSD property development activities. The SDG&E design basis is based on one potential candidate location, the parking lot southeast of Genesee Ave and Campus Point Drive, "Voight Parking Lot." The Project goal is to safely blend hydrogen into an isolated test loop of new natural gas pipe and collect relevant data on its impact. The blended gas will feed into a fuel cell that will provide electricity back to the SDG&E grid.

The Project will begin by observing 100% natural gas in the new loop. Once that baseline is established, SDG&E plans to blend and inject hydrogen into the system, starting at 5% hydrogen by volume and increasing up to 20% by volume over time. Throughout the Project, SDG&E will monitor for leakage and perform testing on safety, material impacts, emissions, and other related impacts as outlined in its detailed project plan.

The Project will be divided into four chronological phases. The Phases are briefly summarized in the table below; certain phases overlap. Timing and duration of the Project phases are estimated and subject to change. Stakeholder engagement is ongoing throughout the Project.

PHASE & ACTIVITY	DESCRIPTION	DURATION
1. Planning, Design, Construction and Commissioning	Hydrogen production and blending equipment is procured; system is designed, constructed, permitted, and commissioned; PE pipe and meters installed, inspections and any necessary remediation are conducted; stakeholder engagement continues.	24 months
2. Testing and Demonstration	Hydrogen is blended in system on a testing schedule; data is collected; periodic inspection of equipment and pipelines; samples of pipelines and components are collected.	24 months (18 months live blending, + 6 months asset inspection & validation)
3. Decommissioning & Equipment Removal, and System Restoration	Hydrogen equipment is removed from UCSD property and property is restored.	5 months
4. Knowledge Sharing	Data from pilot is interpreted and disseminated; a public report will be released.	9 months

Figures 1 and 2 respectively show the project layout, and a potential plot plan for a candidate site on UCSD property. The final site location will be determined by the parties prior to March 31, 2025.

Figure 1: Preliminary Project Plot Plan of Major Hydrogen Equipment

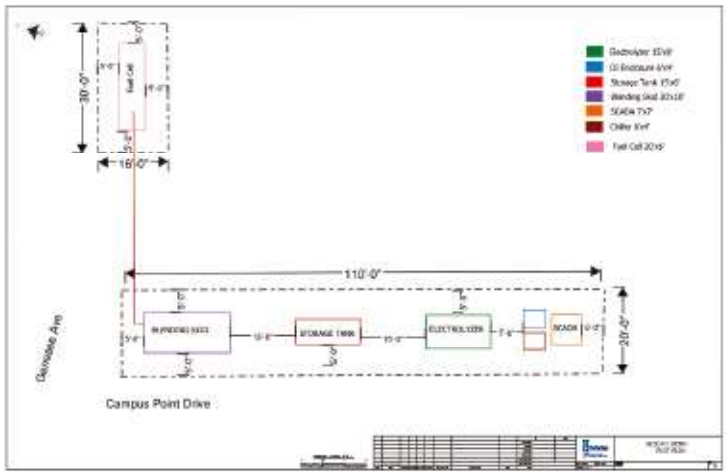

Figure 2: Project Plot Plan of Major Hydrogen Equipment Site Layout on UCSD Property at Candidate Site Used for SDG&E Design Basis