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Witness: H. Mejia, V. Cervantes, and L. Nelson
Chapter: 1

PREPARED DIRECT TESTIMONY OF

HUGO MEJIA, VICTOR CERVANTES, AND LAURA NELSON ON BEHALF OF SOUTHERN CALIFORNIA GAS COMPANY, SAN DIEGO GAS & ELECTRIC COMPANY, AND SOUTHWEST GAS CORPORATION

(POLICY)

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

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CHAPTER 1

PREPARED DIRECT TESTIMONY OF HUGO MEJIA, VICTOR CERVANTES, AND LAURA NELSON

(Policy)

I. PURPOSE

Southern California Gas Company (SoCalGas), San Diego Gas & Electric Company (SDG&E), and Southwest Gas Corporation (Southwest Gas) (collectively, the Applicants) seek approval of an application proposing live hydrogen blending demonstration projects (Projects) to collect necessary safety and integrity data in support of the development of a hydrogen injection standard (Application). Resultant project data can provide key technical, operational, and safety information to support the development of a future hydrogen injection standard of up to 20% hydrogen gas by volume.

The purpose of this chapter's testimony is to provide the policy justification and context for how hydrogen blending could be an essential component of California's carbon neutral energy economy, as well as describe the immediate need to begin testing and understanding live hydrogen injection and blending on the gas system, consistent with recommendations from the "Hydrogen Blending Impacts Study" completed by the University of California (UC), Riverside, for the California Public Utilities Commission (CPUC or Commission). This testimony will elaborate on how blending supports state energy policy objectives, provides an overview of hydrogen market development leadership in the United States (U.S.) and California, and details how Applicants' Projects are unique and distinguishable from other hydrogen blending research efforts in California.

II. LEVERAGING THE APPLICANTS' EXISTING GAS SYSTEMS TO INJECT AND BLEND HYDROGEN COULD HELP ACCELERATE THE DEVELOPMENT OF A CLEAN FUELS NETWORK

A. Introduction

Applicants support California's climate and energy goals, including Senate Bill (SB) 32,[1]

[1] California Senate Bill 32 (Pavley, 2016), *available at:* https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB32.

achieving carbon neutrality by 2045 (E.O. B-55-18),[2] and fulfilling the 100% Clean Energy Act of 2018 by 2045 (SB 100).[3] Applicants acknowledge various challenges that will need to be addressed to meet these targets, and recognize that both clean molecules and clean electrons, as well as a diverse energy technology toolkit, will likely be required to reach carbon neutrality while providing safe, reliable and resilient energy.

Hydrogen is poised to become an essential component of the low carbon energy economy of the future. In California and other parts of the world, hydrogen can be integral to achieving energy decarbonization at scale. The flexibility of hydrogen as an energy carrier across multiple sectors makes it a unique carbon neutral energy solution enabling transportation, distribution, and storage of clean energy. By decarbonizing multiple sectors of the economy, hydrogen is uniquely positioned to transform California's future energy system. At its July 2021 workshop, the California Energy Commission ("CEC") recognized the importance of hydrogen, stating "[A]s we look at different options and alternatives for the state to transition to a decarbonized electricity system by 2045, hydrogen has emerged as an important element that we need to assess and understand," especially for grid reliability.

Blending hydrogen has the potential to lower greenhouse gas (GHG) emissions on both the electric and gas grids, serve as a low-cost hydrogen storage and transportation medium, and provide system resiliency through energy diversity and redundancy. For example, as indicated in Figure 1 below, the existing gas system could be leveraged to deliver clean molecules to many sectors of the economy, including heavy duty transportation, high heat for industrial applications, power and heat for buildings, and clean, firm dispatchable power for electric generation. In the future, hydrogen separation technology may be added to the system for specific end point applications requiring pure hydrogen fuel.

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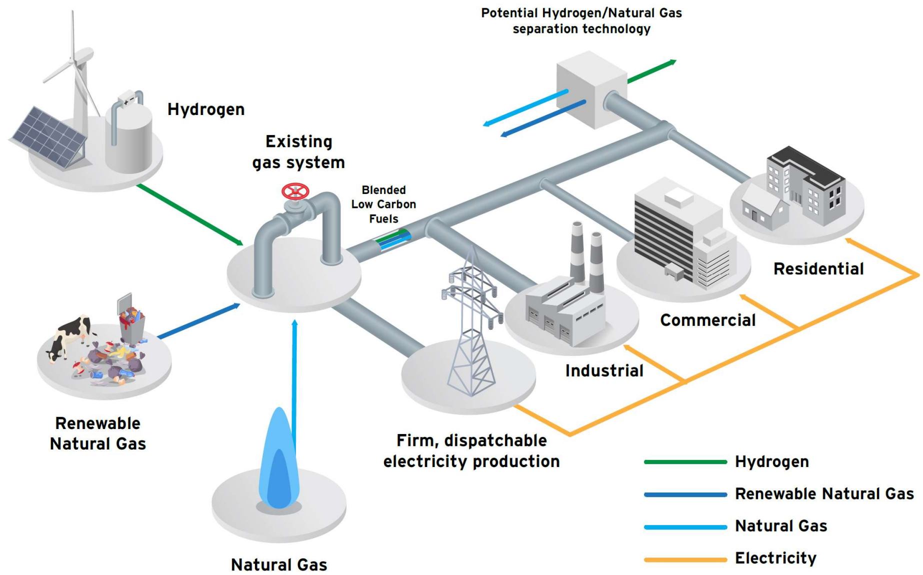
[2] Executive Dept., State of California, "Executive Order B-55-18 To Achieve Carbon Neutrality" *available at:* https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf.

[3] California Senate Bill 100 (De León, 2018), *available at*: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100.

Figure 1: Hydrogen Blending on the Existing Gas System



Since hydrogen is carbon-free at the point of consumption, it could make a significant contribution to lower emissions in various sectors of the economy. For example, at a 20% hydrogen blend by volume, the typical carbon dioxide (CO_2) reduction potential of hydrogen is 6.3%.[4] Given the scale of the gas system today, a 6.3% CO_2 reduction is significant: if California's gas system was 20% hydrogen by volume in 2020,[5] the CO_2 reduction would be equivalent to removing 1.52 million gasoline-powered passenger vehicles from the road, or

[4] International Energy Agency, *Reduction of CO_2 Emissions by Adding Hydrogen to Natural Gas. Report No. PH4/24* (October 2003), *available at:* https://ieaghg.org/docs/General_Docs/Reports/Ph4-24%20Hydrogen%20in%20nat%20gas.pdf.

[5] As of May 10, 2022, the 2022 California Air Resources Board's (CARB) Draft Scoping Plan Update's selected Proposed Scenario (Alternative 3) includes renewable hydrogen blended in natural gas pipelines at 7% energy (~20% by volume), ramping up between 2030 and 2045. [5] California Air Resources Board, *Draft 2022 Scoping Plan Update* (May 10, 2022), *available at:* https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp.pdf.

replacing about 6% of California's registered automobiles with zero emission vehicles.[6,7,8,9]

The establishment of a hydrogen blending injection standard could accelerate the adoption of clean fuels and get California closer to achieving broader energy system decarbonization. California's hydrogen economy is poised for accelerated growth, and hydrogen blending could secure California's place beside other global clean energy leaders. The development of a blending standard could signal California's market is open for business and attract the investments needed to reduce production costs and bring it to scale. In addition, blending hydrogen into our existing system could provide an opportunity for our existing workforce to adopt safe operating practices and participate in the clean hydrogen economy future.

B. Delivering Clean Fuels as a Potential Strategy to Timely and Cost-Effectively Meet State's Climate Goals

Leveraging existing pipelines is one of the most cost-effective and timely ways to serve clean fuels to our electric power, industrial, commercial, and residential customers. This position is supported by the findings and recommendations outlined in the June 2020 UC Final Project Report prepared by the University of California (UC) Irvine's Advanced Power and Energy Program for the CEC.[10] One of the top UC Irvine recommendations is to "[p]romote access to the natural gas system for renewable hydrogen transport and storage—establish blending limits

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[6] U.S. Energy Information Administration, *Natural Gas Delivered to Consumers in California*, *available at:* https://www.eia.gov/dnav/ng/hist/n3060ca2m.htm.

[7] U.S. Environmental Protection Agency, *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, *available at:* https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle.

[8] California Department of Motor Vehicles, *Estimated Vehicles Registered by County for the Period of January 1 through December 31, 2020*, *available at:* https://www.dmv.ca.gov/portal/uploads/2021/02/estimated_fee_paid_by_county_report.pdf.

[9] Calculation: (2,019 BCF of natural gas consumed in CA 2020)*(0.0552 kg CO2/CF) produces 112.16 MMT CO2/year from natural gas system. If 20% of the natural gas by volume had been replaced by hydrogen: 6.3%*111MMT CO2 = 7.0 MMT of CO2 emissions could have been avoided. In passenger vehicle equivalency, (7.0 MMT of CO2*10^6)/4.5 MT CO2/car/year (per EPA average)= 1,524,280 cars removed from the road. As there were 25,507,660 registered cars in California in 2020, this is equivalent to removing 6% of all cars from the road in California.

[10] University of California, Irvine, Advanced Power and Energy Program, *Roadmap for the Deployment and Buildout of Renewable Hydrogen Production Plants in California* (June 2020), *available at:* https://www.apep.uci.edu/PDF_White_Papers/Roadmap_Renewable_Hydrogen_Production-UCI_APEP-CEC.pdf.

and interconnection requirements."[11] The report urges timely action so that renewable hydrogen fuel producers receive the same open access to the common-carrier pipeline system as other fuel types and recognizes the Commission's critical role in enabling this.[12]

In October 2021, SoCalGas published a report titled "The Role of Clean Fuels and Gas Infrastructure in Achieving California's Net Zero Climate Goal."[13] The study compared four future energy scenarios for California, ranging from "high clean fuels" to "full electrification," which considered fully decommissioning the fuels network. The results demonstrated that in the three scenarios featuring a clean fuels network, California's energy system would be more affordable, resilient, and carry less technology risk than the "no fuels network" (aka "full electrification") scenario. Notably, the study projected that clean fuel systems, comprised of increasing levels of clean molecules, including higher blend rates of hydrogen into the existing pipeline along with dedicated hydrogen pipelines, would save California energy customers between $45 billion and $75 billion over the course of the next 30 years in avoided costs that would otherwise be needed without a clean fuels network. To unlock these savings and help Californians receive highest return on investment for a reliable and resilient path to net zero emissions, Applicants recognize significant innovation and infrastructure investment is required. In this respect, the demonstration Projects detailed in Chapters 2-4, comprising live evaluation of hydrogen blending in sections of the present gas distribution system inform the critical path to efficiently achieving statewide climate goals.

In April 2022, SDG&E published a study, "The Path to Net Zero: A Decarbonization Roadmap for California," which shared its vision on how to decarbonize the California economy while also prioritizing grid reliability, affordability, and equity. The SDG&E study evaluated several combinations of decarbonization strategies, which included clean fuel pipeline blending, designed to achieve the state's goals over the study horizon. Based on that effort, SDG&E's position is that the composition of fuel in the pipeline in 2045 is likely to be comprised of a blend of natural gas, renewable natural gas (RNG), and clean hydrogen, while acknowledging a

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[11] *Id*. at 6.
[12] *Id.* at C-24.
[13] SoCalGas, *The Role of Clean Fuels and Gas Infrastructure in Achieving California's Net Zero Climate Goal* (October 2021), *available at:* https://www.socalgas.com/sites/default/files/2021-10/Roles_Clean_Fuels_Full_Report.pdf.

significant decline of gas system throughput due to broad electrification of the building sector.[14]

Importantly, while the 2045 costs of hydrogen are uncertain and challenging to predict over such a long-time horizon, clean hydrogen is likely to be a competitively priced fuel by 2045. Analysis by the Hydrogen Council, in collaboration with McKinsey, prior to the U.S. Department of Energy's (DOE) "Hydrogen Shot" announcement, found that the production costs of green hydrogen could decline by 60% from 2020 to 2030 in the U.S.[15] This is because clean hydrogen production, including that which qualifies as renewable or "green," is well positioned to benefit from massive economies of scale.

The downward cost trajectory of clean hydrogen is further accelerated and solidified by the new clean hydrogen production tax credit within the Inflation Reduction Act (IRA) passed by the U.S. Congress on August 12th, 2022. Low carbon-intensity hydrogen reaches a maximum credit value of $3.00/kg, enabling cost to reach parity or fall below the cost of conventional grey hydrogen by 2030 (Figure 3).[16] With this powerful economic incentive in place, clean hydrogen is ideally positioned for widespread deployment across California. Hydrogen blending could play a major role in this process by providing producers with a viable alternative to transport clean hydrogen by leveraging the existing gas system, and at the same time, by enabling California to benefit from clean, federally subsidized hydrogen to progress towards its climate goals.

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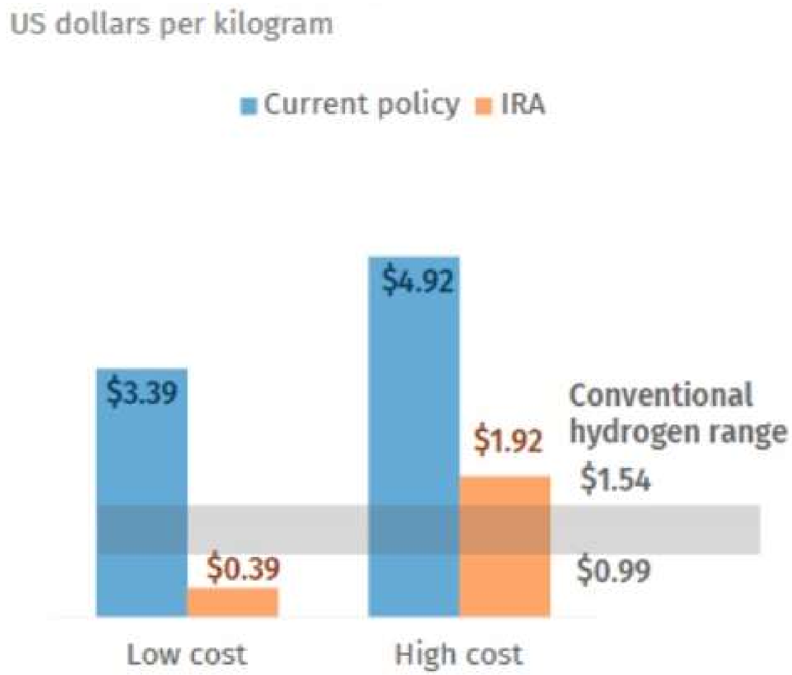
[14] San Diego Gas & Electric, *The Path to Net Zero: A Decarbonization Roadmap for California* (April 2022), *available at*: https://www.sdge.com/netzero

[15] Hydrogen Council and McKinsey & Company, *Hydrogen Insights: A perspective on hydrogen investment, market development and cost competitiveness* (February 2021), *available at:* https://hydrogencouncil.com/wp-content/uploads/2021/02/Hydrogen-Insights-2021-Report.pdf.

[16] Rhodium Group, *A Turning Point for US Climate Progress: Assessing the Climate and Clean Energy Provisions in the Inflation Reduction* Act (August 2022), *available at:* https://rhg.com/research/climate-clean-energy-inflation-reduction-act/.

Figure 3: Forecasted Clean Hydrogen Prices in 2030, with and without IRA Clean Hydrogen Production Tax Credit



C. Hydrogen Blending Could Reduce Emissions in Multiple Sectors

As a carbon-free fuel, hydrogen could help reduce GHG emissions from multiple sectors of the economy currently fueled by natural gas from the power sector to the industrial sector, to buildings (commercial and residential).

<u>Power Sector</u>

Currently, natural gas fired generators are needed to support the state with firm, dispatchable electric power. In 2020, 30% of the state's total natural gas consumption went to electricity production.[17] Hydrogen blended with natural gas could support the transition to carbon-neutral electricity by 2045 by lowering CO_2 emissions from existing natural gas-powered generators over the next 20 years. Power producers and utilities in the state are studying or

[17] U.S. Energy Information Administration, *Natural Gas Consumption by End Use, California, Annual, available at:* https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm.

executing this option to support a phased transition. Turbine manufacturers including Mitsubishi, General Electric (GE), and others either currently offer or are working on designs to allow for power production with a high content of blended hydrogen.[18] For example, Solar Turbines Incorporated, with DOE funding and support from Pipeline Research Council International (which SoCalGas is a member of), is developing a retrofittable dry low emissions gas turbine combustion system that can operate with hydrogen blends and 100% hydrogen.[19] Another example is the Los Angeles Department of Water and Power's conversion of a power plant in Delta, Utah to operate on a blend of 30% hydrogen and 70% natural gas by 2025, using turbines supplied by Mitsubishi Power.[20] SDG&E is preparing to blend hydrogen at its Palomar Energy Center 565 megawatt combined cycle plant in the next year, using existing turbine technology.[21]

In addition to reducing power sector CO_2 emissions, hydrogen blending on the gas system could support renewable resource integration while increasing the efficiency and reliability of the electric grid.

Electrolytic hydrogen production could take advantage of low-cost, excess renewable energy when it is available to create clean hydrogen gas. In addition to utilizing excess renewable energy that is otherwise curtailed, that clean hydrogen gas could be stored in pipelines and dispatched back to the grid in the form of electricity when required via turbines or fuel cells. California is seeing a large increase in curtailed clean energy. For example, between 2018 and 2019 alone, the amount of curtailed energy from solar and wind in California more than doubled, according to the California Independent System Operator (CAISO).[22] If curtailed resources were paired with electrolyzers, the otherwise wasted energy could be used to create hydrogen.

Hydrogen could meaningfully contribute to power sector reliability and resiliency owing

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[18] Mitsubishi Hydrogen Power Generation Handbook (2021); GE Power to Gas: Hydrogen for Power Generation (2019).

[19] National Energy Technology Laboratory, *U.S. Department of Energy Selects 12 Projects to Improve Fossil-Based Hydrogen Production, Transport, Storage and Utilization, available at:* https://netl.doe.gov/node/10875.

[20] Los Angeles Times, *This Tiny Utah Town Could Shape West's Energy Future* (Sammy Roth, May 19, 2022) *available at:* https://www.latimes.com/environment/newsletter/2022-05-19/this-tiny-utah-town-could-shape-the-wests-energy-future-boiling-point.

[21] San Diego Gas and Electric, *Powering the future: Palomar Energy Center Green Hydrogen Project available at:* https://www.sdgenews.com/article/powering-future-palomar-energy-center-green-hydrogen-project.

[22] California Independent System Operator, *Managing oversupply*, *available at:* http://www.caiso.com/informed/Pages/ManagingOversupply.aspx.

to its superior capability as a long duration energy storage medium. Many existing electrochemical battery technologies have operating profiles in minutes to hours, and are unable to meet the challenge of weekly or seasonal balancing of the grid that will be needed as the state moves toward higher penetrations of renewables. In contrast, hydrogen is a very long-duration (weeks to months) and scalable (from megawatts to gigawatts) energy storage medium that could become a critical solution to avoid curtailment and provide reliability to the future net-zero electric grid.

Industrial Sector

Hydrogen is an attractive carbon free energy solution for industries that cannot rely on electrification alone because they depend on fuels to create process heat and steam. Examples of these industries include makers and processors of iron, steel, aluminum, glass, paper, cement, and food. California's industrial sector makes up over 10% of the state's economy, with a total manufacturing output of $324 billion in 2019.[23] Much of this sector relies on the natural gas system for fuel; a full 34% of California's gas consumption supported industrial processes in 2020. Blending hydrogen into the natural gas system could support industrial decarbonization in the short to medium term by lowering overall emissions, while also protecting the state's manufacturing economy. Ultimately, it is anticipated that industries will likely seek to form or organize clusters around dedicated hydrogen pipelines, but hydrogen blending is a complementary strategy that could be implemented more rapidly.

Building Sector (Commercial and Residential)

To date, minimal efforts to promote clean fuels development have been directed at end-use customers, specifically in commercial and residential buildings, which accounted for a total of 35% of natural gas consumption in 2020 (12% and 23% respectively).[24] These customers include individuals and major corporations who are increasingly interested in reducing their environmental impact but may not be able to afford new appliances or are waiting for their current appliances to achieve end of life. As these customers increasingly demand access to

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[23] National Association of Manufacturers, *2021 California Manufacturing Facts*, *available at:* https://www.nam.org/state-manufacturing-data/2021-california-manufacturing-facts/.
[24] U.S. Energy Information Administration, *Natural Gas Consumption by End Use, California, Annual, available at:* https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm.

renewable energy, the gas pipeline system, through the integration of hydrogen blending, could be viewed as a resource in California's clean energy strategy by delivering clean molecules for end-use energy consumption. Leveraging the gas pipeline system enables built-in resiliency while supporting customers in the clean energy transition.

D. Real World Demonstration Scale Testing Is Necessary to Support the Development of a Hydrogen Blending Injection Standard

The Commission has acknowledged that "existing efforts and research status on hydrogen affirm that the issue is ripe for consideration."[25] The Commission has also indicated that any impacts to the safety of the gas systems or to customer end-uses must be clearly understood and mitigated (in addition to the impacts and benefits on the environment and to customers) before a hydrogen injection standard can be implemented. The Applicants agree with this position and are undertaking steps to achieve this end, leveraging recently set forth recommendations from the "Hydrogen Blending Impacts Study" completed by UC Riverside Study for the Commission.[26] As an outcome of their findings, UCR recognized that a single, systemwide injection standard would have to consider the most susceptible conditions observed through all infrastructure components as well as end-uses, appliances, and industrial processes. The study further highlights "as there are knowledge gaps in several areas, including those that cannot be addressed through modeling or laboratory scale experimental work, it is critical to conduct real world demonstration of hydrogen blending under safe and controlled conditions." UCR recommended that the utilities:

"Conduct demonstration of hydrogen blending in a section of the infrastructure that is isolated or is custom-built to include the commonly present materials, vintages, facilities, and equipment of the generic California natural gas infrastructure with appropriate maintenance, monitoring and safety protocols over extended periods. The recommended hydrogen percentages for this demonstration are 5 to 20%. Such demonstration projects can allow critical knowledge gaps to be filled, including the effect of parameters such as weather induced temperature

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[25] Assigned Commissioner's Scoping Memo and Ruling Opening Phase 4 of Rulemaking 13-02-008 (November 21, 2019) at 7, *available at:* http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M320/K307/320307147.PDF.

[26] Raju, A.S.K, *Hydrogen Blending Impacts Study*, prepared for the California Public Utilities Commission, July 2022.

changes, pressure cycling, length of exposure, effect of natural gas components and contaminants, and potential mitigation techniques."

Per these recommendations, the Applicants' proposed Projects can demonstrate hydrogen blends in the 5-20% range considering this is the range at which little to no modifications are required to end-use equipment and hydrogen blending is unlikely to impact safety and operation of end-use appliances considering comparable field testing performed in the United Kingdom.[27] The Projects proposed by the Applicants can inform stakeholders of the critical safety, technical and operational data that will support these parallel efforts. The Applicants also intend to collaborate with stakeholders on these recommended parallel efforts given the opportunity.

In addition to the Commission's interest, California's other leading energy, environmental, and economic development agencies, including the California Energy Commission (CEC), CARB, and the Governor's Office of Business and Economic Development, have all recognized hydrogen's ability to help the state meet its decarbonization goals. Across agencies, hydrogen development has been funded, studied, and proposed in a variety of programs, policies, and proceedings.

While these efforts are important, understanding the safety and operational impact of live hydrogen blending on the existing gas system is necessary to develop a safe hydrogen injection standard at appropriate hydrogen blending percentages which utilize existing and planned infrastructure, and work with customer end-use appliances. The establishment of a hydrogen injection standard could enable the state to effectively and safely utilize hydrogen to meet its phased energy transition goals in a timely manner. The Application and the Projects it seeks to authorize serve as the critical lynchpin supporting all other hydrogen efforts in the state.

As the foundational stage in a long-term hydrogen blending blueprint, "real-world" blending Projects in this Application can demonstrate practical, distribution-scale implementation in support of an injection standard of up to 20% in some parts of the distribution system. Project results can guide the Applicants to define the parameters of potential transmission-scale blending demonstrations in follow-on phases of the process, towards the

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[27] HyDeploy, *First UK trial of hydrogen blended gas hailed a success* (September 8, 2021), *available at*: https://hydeploy.co.uk/about/news/first-uk-trial-of-hydrogen-blended-gas-hailed-a-success/.

objective of an injection standard for hydrogen blending in the entire gas system.

Therefore, it is urgent that we begin studying the behavior and impact of live hydrogen blending in the existing natural gas system today, as it will take time to collect and analyze those results. The Applicants cannot solely rely on bench testing, literature reviews, or results from demonstrations conducted out of state, given that no two gas systems are identical. The Applicants must develop the required level of operational hydrogen blending expertise and experience as soon as possible to establish an injection standard, so that the gas system could incorporate clean hydrogen for blends up to 20% in support of a phased approach toward gas decarbonization through 2045 and beyond.

Depending on the data gathered while the Projects are in progress, the Applicants may have enough information collected to develop an interim preliminary hydrogen blending standard for the California gas distribution system. The interim standard could expedite the adoption of lower carbon fuels in California. The Applicants will share information on a potential interim standard with the Commission as it becomes available.

III. RECENT HYDROGEN MARKET DEVELOPMENT LEADERSHIP IN U.S. AND CALIFORNIA

In the last two years, the U.S. and California have seen a considerable increase in interest, investment, and activity around clean hydrogen for use in decarbonizing the electric and gas sectors. By being one of the first states to develop a comprehensive hydrogen injection standard for up to 20% hydrogen in the existing natural gas network, California will be well positioned to benefit from federal funding programs and private investment in the hydrogen sector. Developing such a standard also sends a clear signal that California's hydrogen economy is open for business. Not only would this accelerate the low carbon hydrogen economy, but it would also create a major new economic engine for clean energy development in the state, including an entirely new industry for skilled workers and massive potential clean energy export opportunities. According to a recent study by the Fuel Cell & Hydrogen Energy Association, the U.S. hydrogen economy could generate an estimated $140 billion per year in clean energy revenue and support 700,000 total jobs across the hydrogen value chain by 2030.[28] By 2050, it could drive growth by generating about $750 billion per year in revenue and a cumulative 3.4 million jobs.[29]

U.S. Government Leadership

The Federal Government has provided major signals over the last two years indicating its endorsement for the development of a clean hydrogen economy.

For example, on June 7, 2021, the DOE announced its first "Earthshot" initiative, focused on clean hydrogen. The initiative seeks to reduce the cost of clean hydrogen by 80% to $1 per 1 kilogram in 1 decade ("1 1 1"). If the Hydrogen Shot goals are achieved, scenarios show the opportunity for at least a five-fold increase in clean hydrogen use. A U.S. industry estimate shows that the increased use of clean hydrogen has the potential for 16% carbon dioxide emission reduction economy-wide by 2050, in addition to major economic benefits.[30]

On November 15, 2021, the U.S. Congress passed the Infrastructure Investment and Jobs Act (IIJA), which lays the foundation for a national clean hydrogen strategy and roadmap. The IIJA allocates $9.5 billion in funds toward development of the hydrogen energy economy and, importantly, establishes a federal definition for clean hydrogen.[31] The new federal law defined "clean hydrogen" as "[h]ydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced."[32] The IIJA further mandated the development of a national strategy to facilitate a clean hydrogen economy, the National Clean Hydrogen Strategy and Roadmap, and directed the development of a clean hydrogen production carbon intensity standard.

On August 12, 2022, the U.S. Congress passed the Inflation Reduction Act, which strengthens even further the foundation for the development of the U.S. hydrogen economy. The IRA creates a new clean hydrogen production tax credit of up to $3 per kilogram of hydrogen

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[28] Fuel Cell & Hydrogen Energy Association (FCHEA), *Roadmap to a US Hydrogen Economy: Reducing emissions and driving growth across the nation* (November 2019), *available at:* https://www.fchea.org/us-hydrogen-study.
[29] *Id.*
[30] Office of Energy Efficiency & Renewable Energy – Hydrogen and Fuel Cell Technologies Office, *Hydrogen Shot*, *available at*: https://www.energy.gov/eere/fuelcells/hydrogen-shot.
[31] Infrastructure Investment and Jobs Act, Pub. L. No. 117-58, 135 Stat. 429 (2021), *available at:* https://www.congress.gov/bill/117th-congress/house-bill/3684/text.
[32] *Id*. at § 40312 (amending § 803 of the Energy Policy Act of 2005, codified at 42 U.S.C. § 16152).

produced that will likely dramatically improve the competitiveness of clean hydrogen and accelerate its deployment across the U.S.

California Leadership

As described below, California's Legislature and Governor's Office, as well as leading energy, environmental, and economic development agencies, have all recognized hydrogen for its ability to help the state to timely and affordably meet its decarbonization goals. Hydrogen efforts have been funded, studied, and proposed in a variety of programs, policies, and proceedings. However, it is Applicants' position that a fundamental and timely understanding of live hydrogen blending on the existing gas network of up to 20% hydrogen is necessary to safely achieve the ambitious hydrogen market development and decarbonization goals that these agencies and regulatory and lawmaking bodies are working towards.

Some recent hydrogen-related efforts at the state level and at key state agencies are summarized here.

California's Legislature

California lawmakers have passed a variety of legislation to encourage market development of hydrogen. Recently passed bills include:

- SB 1505 (2006) – Authorized CARB as the authority to regulate the emissions and renewable content of hydrogen produced for fuel cell electric vehicles (FCEV) and mandated that 33.3% of the hydrogen supplied through the state's fueling infrastructure be made from "eligible renewable energy resources" as determined by the Public Utilities Code.
- Assembly Bill (AB) 118 (2007) – Created the CEC's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP).
- AB 8 (2013) – Mandated $20 million in annual funding (from the ARFVTP) to support the construction of 100 hydrogen-fueling stations.
- AB 1369 (2018) – Authorized green electrolytic hydrogen an eligible form of energy storage.

Additionally, the Legislature recently passed several budget trailer bills on August 31, 2022 to further advance hydrogen system market development opportunities including allocation of $100 million to create a state Hydrogen Program to provide financial incentives to eligible in-state hydrogen projects for the demonstration or scale-up of the production, processing, delivery, storage, or end use of hydrogen, and $5 million to the Alliance for Renewable Clean Hydrogen Energy Systems initiative for activities related to establishing a federally-funded hydrogen hub in California.

Governor's Office

- Executive Order S-01-07 created the Low Carbon Fuel Standard (LCFS) program, directing CARB to meet a target of at least 10% reduction in the carbon intensity (CI) of California's transportation fuels by 2020.
- Executive Order B-48-18 doubled the State's construction goal for hydrogen stations, establishing new targets of 200 stations and 5 million total zero-emission vehicles on California roads by 2030.
- On May 18, 2022, Governor Newsom's administration announced California's intention to leverage federal investment from the IIJA to establish an environmentally and economically sustainable and expanding renewable hydrogen hub.[33]

The Governor's Office of Business and Economic Development ("GO-Biz")

- GO-Biz serves as California's leader for job growth, economic development, and business assistance efforts.
- H2Hubs effort: Go-Biz is leading the H2Hubs effort in strong collaboration with stakeholders across sectors, building a collaborative ecosystem of technology, policy, and finance partners to develop a winning proposal for a green hydrogen hub, and more broadly, to advance and accelerate the hydrogen market within the state and beyond.[34] GO-Biz formally announced California's intention to leverage federal investment for the IIJA to establish an environmentally and economically sustainable and expanding renewable hydrogen hub and they are eyeing Los Angeles as a target geographic

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[33] Bloomberg, *California to Join $8 Billion Hydrogen Hub Race Among US States*, (May 18 2022), *available at:* https://www.bloomberg.com/news/articles/2022-05-18/california-to-join-8-billion-hydrogen-hub-race-among-us-states.

[34] State of California, *California H2Hub Collaborator Form*, *available at:* https://business.ca.gov/h2hubs-form/.

location.[35]

- Hydrogen Fueling Station Readiness: As part of the Go-Biz Zero Emission Vehicles (ZEVs) program, there is a team specifically dedicated to cultivating opportunities to accelerate zero-emission vehicle market growth, including hydrogen ZEVs.[36]

California Energy Commission

The CEC is the state's primary energy policy and planning agency. It is committed to reducing energy costs and environmental impacts of energy use while ensuring a safe, resilient, and reliable supply of energy. It has included hydrogen in a variety of efforts over the past years. Examples include:

- 2021 Integrated Energy Policy Report, Volume III - Decarbonizing the State's Gas System.[37]
- Hydrogen Vehicles & Refueling Infrastructure Programs and Grant Funding Opportunities;[38] with an increased focus to include onsite hydrogen generation.
- Block Grant for Medium-Duty and Heavy-Duty Zero-Emission Vehicle Refueling Infrastructure Incentive Projects.[39]
- CEC GFO 21-507: Targeted Hydrogen Blending in Existing Gas Systems.[40]
- CEC GFO 21-503: Examining the Effects of Hydrogen in End Use Appliances for Large

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[35] State of California, *California Formally Announces Intention to Create a Renewable Hydrogen Hub* (May 18, 2022), *available at:* https://business.ca.gov/california-formally-announces-intention-to-create-a-renewable-hydrogen-hub/.
[36] State of California, *Zero-Emission Vehicles (ZEV*), *available at:* https://business.ca.gov/industries/zero-emission-vehicles/.
[37] California Energy Commission, *2021 Integrated Energy Policy Report, available at:* https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report.
[38] California Energy Commission, *Hydrogen Vehicles & Refueling Infrastructure, available at:* https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program/clean-transportation-funding-areas-1.
[39] California Energy Commission*, Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE Commercial Vehicles), available at:* https://www.energy.ca.gov/proceedings/energy-commission-proceedings/energy-infrastructure-incentives-zero-emission-commercial.
[40] California Energy Commission, *GFO-21-507 - Targeted Hydrogen Blending in Existing Gas Network for Decarbonization, available at:* https://www.energy.ca.gov/solicitations/2022-01/gfo-21-507-targeted-hydrogen-blending-existing-gas-network-decarbonization.

Commercial Buildings and Industrial Applications.[41]

- Natural Gas Research and Development Program: Annually established scope of projects that has increasingly focused on hydrogen technologies. The latest Budget Plan (Fiscal Year 2022-2023) includes a total of $13 million in funding for hydrogen related activities, including: (1) large-volume hydrogen storage projects for targeted use cases; (2) industrial clusters for clean hydrogen utilization; (3) funding to mitigate criteria air pollutants in hydrogen combustion; and (4) advanced hydrogen refueling for heavy transport refueling infrastructure solutions.[42]

California Air Resources Board

CARB is the lead agency for climate change programs and oversees all air pollution control efforts in California to attain and maintain health-based air quality standards. CARB has included hydrogen in a variety of efforts over the past few years. Examples include:

- CARB Scoping Plan (AB 32): In 2006, the Legislature passed the California Global Warming Solutions Act of 2006 (AB 32), which created a comprehensive, multi-year program to reduce GHG emissions in California. AB 32 required CARB to develop a Scoping Plan that describes the approach California will take to reduce GHGs to achieve the goal of reducing emissions to 1990 levels by 2020. The Scoping Plan was first approved by CARB in 2008 and must be updated at least every five years. Since 2008, there have been two updates to the Scoping Plan. Each of the Scoping Plans have included a suite of policies to help the state achieve its GHG targets, in large part leveraging existing programs whose primary goal is to reduce harmful air pollution. As mentioned earlier in this testimony, the 2022 CARB Draft Scoping Plan Update's selected Proposed Scenario (Alternative 3), as of May 10, 2022, includes renewable hydrogen blended in natural gas pipeline at 7% energy (~20% by volume), ramping up

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[41] California Energy Commission, *GFO-21-503 - Examining the Effects of Hydrogen in End-Use Appliances for Large Commercial Buildings and Industrial Applications, available at:* https://www.energy.ca.gov/solicitations/2021-09/gfo-21-503-examining-effects-hydrogen-end-use-appliances-large-commercial.

[42] California Energy Commission, *Gas Research and Development Program Proposed Budget Plan for Fiscal Year 2022–23* (March 2022), *available at:* https://www.energy.ca.gov/sites/default/files/2022-03/CEC-500-2022-001.pdf.

between 2030 and 2045.[43]

- GHG Emission Inventory Program (AB 32).
- Hydrogen Fueling Infrastructure Report (AB 8).
- LCFS (AB 32).
- ZEV Program (Advanced Clean Cars, State Agency ZEV Action plans, California's ZEV Market Development Strategy EO N-79-20).

Other State and Provincial Leadership

Although California is widely recognized for its international leadership in clean energy policy, when it comes to hydrogen blending, Europe, Australia, other U.S. states and Canadian provinces have taken more tangible action, with an understanding that incremental blending of hydrogen into natural gas energy systems will provide a seamless and more resilient transition towards carbon neutrality. Table 1 summarizes the extensive list of hydrogen blending demonstration projects occurring outside the U.S.[44] Live hydrogen blending studies and pilots have either been announced or are already underway in the U.S. and Canada. These projects are occurring in Minnesota (CenterPoint Energy blending up to 5% H2 into local gas distribution system)[45]; New York (National Grid's "HyGrid" blending pilot in Hempstead, NY); New Jersey (NJ Natural Gas's blending pilot in Howell, NJ)[46], New Mexico (New Mexico Gas Company)[47]; Ontario (Enbridge Gas in Markham, Ontario, Canada)[48], Utah (Dominion ThermH_2™

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[43] California Air Resources Board, *Draft 2022 Scoping Plan Update* (May 10, 2022), *available at:* https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp.pdf.

[44] Mahajan, D.; Tan, K., et al. Hydrogen Blending in Gas Pipeline Networks – A Review, *Energies*, 2022, **15**, 3582.

[45] CenterPoint Energy, *Renewable Hydrogen: Accelerating a Cleaner Energy Future*, *available at:* https://www.centerpointenergy.com/en-us/business/services/clean-energy-innovation/renewable-hydrogen.

[46] New Jersey Natural Gas, *A Clean Energy New Jersey Starts Here: NJNG's Green Hydrogen Project*, *available at:* https://www.njrsustainability.com/environmental/NJR_HydrogenProject_Factsheet_01d1.pdf.

[47] New Mexico Gas Company, *New Mexico Gas Company to Test Hydrogen Blending* (December 3, 2021), *available at:* https://www.nmgco.com/userfiles/files/12%203%2021%20Hydrogen%20Project.pdf.

[48] Enbridge, *Hydrogen blending project now operational, reducing carbon footprint of natural gas delivered by Enbridge Gas* (January 2022), *available at:* https://www.enbridge.com/stories/2022/january/hydrogen-blending-project-enbridge-gas-cummins-operational-markham-ontario.

distribution gas blending project at a training facility)[49], and North Carolina (Dominion Energy in Gastonia, North Carolina). Hawai'i Gas already serves its customers up to 15% hydrogen in its mixed gas system which also consists of synthetic natural gas, RNG, and liquified natural gas (LNG).[50]

Table 1. Rest of World Hydrogen Blending Demonstration Projects.

Project	Country	Year	Blending Vol%	Trial/Project Size
HyDeploy	UK	2019	20	1500 residentials
East Neuk Power	UK	2020	20	15 GWh energy annually
Aberdeen Vision	UK	2020	2–20	300 residentials
HyNet Northwest	UK	2021	100	30 TWh energy annually
HyNTS Hydrogen Flow Loop	UK	2021	30	-
H21	UK	2018	100	6.4 TWh energy annually
Hy4Heat	UK	2018	100	-
HySpirit	UK	2019	100	-
Zero 2050 South Wale	UK	2020	100	-
Decarbonisation Pathway	UK	2020	100	-
GRHYD	France	2014	20	200 residentials
THyGA	EU	2019	10–100	100 residentials and commercials
WindGas Falkenhagen	Germany	2013	2	-
WindGas Hamburg	Germany	2015	2	-
HyP SA	Australia	2021	5	700 residentials
HyP Gladstone	Australia		10	800 residentials and industrials
HyP Murry Valley	Australia	2021	10	40,000 residentials
Jemena West Sydney	Australia	2018	2	259 residentials
Fort Saskatchewan	Canada	2020	5	2000 residentials
Cummins-Enbridge	Canada	2018	2	3600 residentials

Although California is slightly behind projects announced and underway in other states, a timely approval of the proposed Projects would squarely position California as a leader in hydrogen development due to the scope, diversity, differentiation, impacts, and knowledge sharing of the hydrogen blending initiatives described herein. Further, Commission approval of a statewide hydrogen injection and blending standard could greatly accelerate potential economic growth from hydrogen market development. Such a standard could put California in a strong leading position to benefit from federal dollars and private investment for hydrogen market development. It could also accelerate creation of hydrogen-related new highly skilled jobs and

[49] Dominion Energy, *Hydrogen: The Next Frontier of Clean Energy, available at:* https://www.dominionenergy.com/projects-and-facilities/hydrogen#utah.
[50] Hawai'i Gas, *Decarbonization and Energy Innovation*, *available at:* https://www.hawaiigas.com/clean-energy/decarbonization.

businesses for California.

IV. DISTINGUISHED TECHNICAL APPROACH: LIVE BLENDING

The Projects' overarching goal described in Chapters 2 through 4 of the Application is to support the development of a statewide hydrogen injection standard for California at a hydrogen blending percentage that is compatible with existing and planned gas infrastructure as well as end-use appliances. The Projects have been carefully curated amongst the Applicants so that the investigations are distinguishable from and complementary to each other, the Commission-funded UC Riverside Hydrogen Blending Impacts Study, and the recently launched CEC Grant Funding Opportunity 21-507 (Targeted Hydrogen Blending in Existing Gas Network for Decarbonization). While the UC Riverside and CEC activities are important and support our efforts, they are focused on literature review, tabletop experiments, modeling, risk analysis, and developing performance metrics. They do not include live blending on the gas system, as the subject Projects do. Rather, the Projects build upon the UC Riverside Study by implementing the recommended next step for "real-world" demonstration and development of an injection standard. Specifically, UCR recommends conducting demonstration of hydrogen blending in the 5-20% range utilizing infrastructure that includes commonly present materials, vintages, facilities, and equipment of the generic California natural gas infrastructure with appropriate maintenance, monitoring, and safety protocols over extended periods.

As the companies charged with and dedicated to the safe delivery of energy to our customers and the safety of our workforce, the Applicants agree that the best way to understand and learn how to measure, manage, design, operate, observe, assess, analyze, and mitigate risks associated with the behavior of hydrogen in a blended gas distribution and transmission system, across several materials, is through live blending demonstration projects. Chapters 2 through 4 of the testimony further delve into the details of the proposed live blending projects, which are focused on the distribution system. Applicants agree that multiple distribution-scale projects in different locations represent the lowest-risk and most cost effective first step to evaluate the higher hydrogen blends recommend by the UCR study. Multiple distribution scale projects diversify the learning opportunity across different vintages of pipe, meters, and end-use equipment, the results of which enable more informed potential follow-on transmission scale demonstrations.

The body of literature reports that blending in relatively low hydrogen concentration (1-5% by volume) seems to be viable without significantly increasing risk factors in the storage, transmission, and utilization of hydrogen blends.[51] Successful evaluation of hydrogen blending percentages upwards of 5% proposed in the Projects fill some of the knowledge gaps surrounding materials impacts at higher blending percentages and contribute to a conservative floor for a single injection standard. Per the UC Riverside Study, "[A] single injection standard that applies systemwide would have to consider the most susceptible conditions observed throughout all infrastructure components. This type of scenario would also be required to consider all end-uses, appliances, and associated industrial processes. This systemwide blending injection scenario becomes concerning as hydrogen blending approaches 5% by volume. As the percentage of hydrogen increases, end-use appliances may require modifications, vintage materials may experience increased susceptibility, and legacy components and procedures may be at increased risk of hydrogen effects."

Table 2 below compares and contrasts the activities of UC Riverside and the CEC with the Applicants' proposed activities. While each activity plays a critical role in establishing the knowledge base of hydrogen blending impacts, the Applicants' proposed Projects will establish key findings from the UC Riverside Study under real-world conditions. For example, the Applicants' proposed activities include blending into both steel and polyethylene plastic piping, two of the most prevalent pipeline materials in the California natural gas transportation infrastructure.

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[51] K. Domptail *et al.*, "Emerging fuels – Hydrogen SOTA , Gap Analysis , Future Project Roadmap," 2020.

Table 2: Hydrogen Blending Research Projects Comparison.

Project Title	Description	H2 Blends Considered	Pipeline Detail	End Use Equipment Detail	Location & Climate Detail
UCR Hydrogen Impacts Study	A combination of literature review, modeling, and experimental work was performed on materials and leakage rates. Recommendation: live blending demonstration in 5-20% hydrogen range, create single injection standard blueprint including possibility of <5% blend if deemed necessary to safely operate all infrastructure.	Up to 100% hydrogen	Laboratory material testing- Hydrogen impacts on polymeric materials as well as metals and alloys	Not applicable	Laboratory Test
CEC GFO 21-507	No live blending. Develop strategic experimentation and test program and perform quantitative risk analysis; quantify performance metrics.	Up to 100% hydrogen	Unspecified	Power Generation and Industrial Sectors	N/A
SoCalGas – UCI H2 Blending Pilot	Live blending on isolated portion of system.	Up to 20% by volume	Medium Pressure Distribution Pipeline (Steel and Plastic)	Commercial and Residential	Irvine, CA; Moderate coastal conditions
SDG&E – UCSD H2 Blending Pilot	Live blending on isolated portion of system.	Up to 20% by volume	Medium Pressure Distribution Pipeline (Polyethylene Pipe)	Residential	La Jolla, CA; Moderate coastal conditions

Project Title	Description	H2 Blends Considered	Pipeline Detail	End Use Equipment Detail	Location & Climate Detail
Southwest Gas H2 Blending Pilot	Live blending on isolated portion of system.	Up to 20% by volume	Medium Pressure Distribution Pipeline (Polyethylene Pipe)	Commercial	Truckee, CA; Extremely cold weather conditions

V. CONCLUSION

Hydrogen is an important, but developing, tool in California's clean energy toolkit. If properly employed, it could help accelerate the use of clean fuels in many sectors, allowing for a phased and cost-effective energy transition for all Californians. However, without understanding the safety and operational impact of live hydrogen blending on the existing gas system to develop a safe hydrogen injection standard, it is unlikely that California will be able to effectively and affordably utilize hydrogen to meet its climate goals in a timely manner.

If approved, the projects described in this Application could enable and catalyze a myriad of other hydrogen efforts in the state, including a variety of programs, policies, and proceedings supported by the State Legislature, the Governor's Office, and leading state agencies. The projects included herein are unique, distinguishable from, and complementary to each other and other research underway funded by the state. The Applicants are committed to collaborative knowledge sharing and coordination throughout the projects.

In approving the Application, the Commission can secure California's leadership on hydrogen blending in North America, support the activities and efforts of the state's leading energy, environmental, and economic development agencies and the Legislature, and position the state to benefit from federal dollars and private investment for hydrogen market development.

This concludes our prepared direct testimony.

VI. QUALIFICATIONS

Hugo Mejia

My name is Hugo Mejia. I have been employed by Southern California Gas Company since 1990. I have held various positions at SoCalGas in the Engineering, Environmental, Transmission, Storage, and PSEP organizations. These roles included working as the Engineering Analysis Center Manager, Environmental Services Manager, Gas Transmission Technical Services Manager, Senior Engineer in Storage Operations and PSEP Project and Execution Manager. I am currently employed as the Engineering Hydrogen Manager in Gas Engineering and System Integrity where my primary responsibility is assessment of Hydrogen Blending into the existing natural gas system. I received a Bachelor's Degree in Engineering from California State University, Northridge and I am a Registered Mechanical Engineer in the State of California. I have previously testified before the commission.

Victor Cervantes

My name is Victor Cervantes. My business address is 8690 Balboa Avenue, San Diego, California 92123. In my current role as Director of Hydrogen Business Development, I oversee new business opportunities in the hydrogen sector for San Diego Gas & Electric. Prior to my current position, I was the Business Development Director for the power sector at Sempra Mexico. I have been employed with Sempra Mexico or SDG&E since 2016. Before joining Sempra Mexico, I held various management-level positions in companies in the clean energy sector with work experience in several European and Latin American countries. I hold an MS in Industrial Engineering from the Free University of Brussels (Belgium). I have not previously testified before the California Public Utilities Commission.

Laura Nelson, Ph.D

My name is Laura Nelson. My business address is 1600 East Northern Avenue, Phoenix, Arizona 85020. In my current role as Vice President/Sustainability and Public Policy at Southwest Gas, I am responsible for advancing Environmental, Social and Governance practices, focusing on developing and executing initiatives to help customers achieve their energy and environmental goals, including economy-wide decarbonization. Prior to joining Southwest Gas in May 2022, I was the Vice President of Consulting Services at Strategen and a Special Advisor to the Green Hydrogen Coalition. I have served as the Energy Advisor to two Utah Governors (Governor John Huntsman and Governor Gary Herbert) and worked at various government agencies with a focus on advancing markets for clean energy solutions. I hold both a Ph.D. and Bachelor of Science in Economics from the University of Utah.