**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA**

Order Instituting Rulemaking to Adopt Biomethane Standards and Requirements, Pipeline Open Access Rules, and Related Enforcement Provisions.	Rulemaking 13-02-008 (Filed February 13, 2013)

COMMENTS OF THE NATIONAL FUEL CELL RESEARCH CENTER, GREEN HYDROGEN COALITION, AND CALIFORNIA HYDROGEN BUSINESS COUNCIL TO THE ADMINISTRATIVE LAW JUDGE'S RULING SEEKING COMMENTS REGARDING CONTINUED BIOMETHANE PROCUREMENT REPORTING AND REGARDING UC RIVERSIDE SAFE HYDROGEN INJECTION STUDY

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In accordance with the Rules of Practice and Procedure of the California Public Utilities Commission ("Commission"), the National Fuel Cell Research Center ("NFCRC"), the Green Hydrogen Coalition ("GHC"), and the California Hydrogen Business Council ("CHBC") (together "Joint Parties") hereby submit comments on the Administrative Law Judge's ("ALJ") Ruling Seeking Comments Regarding Continued Biomethane Procurement Reporting and Regarding UC Riverside Safe Hydrogen Injection Study ("Ruling") filed on July 18, 2022.

I. INTRODUCTION

The NFCRC facilitates and accelerates the development and deployment of fuel cell technology and systems; promotes strategic alliances to address the market challenges associated with the installation and integration of fuel cell systems; and educates and develops resources for the decarbonization of power and energy storage sectors. The NFCRC was established in 1998 at the University of California, Irvine ("UCI") by the U.S. Department of Energy and the California Energy Commission in order to develop advanced sources of power generation, transportation and fuels and has overseen and reviewed thousands of commercial fuel cell applications.

GHC is a California educational 501(c)(3) non-profit organization. GHC was formed in 2019 to recognize the game-changing potential of "green hydrogen" to accelerate multi-sector decarbonization and combat climate change. GHC's mission is to facilitate policies and practices that advance green hydrogen production and use in all sectors of the economy to accelerate a carbon-free energy future and a just energy transition. Our sponsors include renewable energy users and developers, utilities, and other supporters of a reliable, affordable green hydrogen fuel economy for all.

The CHBC is a 501(c)(6) non-profit organization comprised of over 135 companies and agencies involved in the business of hydrogen. The CHBC mission is to advance the commercialization of hydrogen in the energy sector, including transportation, goods movement, and stationary power systems to reduce emissions and help the state meet its decarbonization and air quality goals. CHBC enhances market commercialization through effective advocacy and education of policymakers directly and through coalition building.

The Joint Parties applaud the University of California, Riverside ("UCR") for its efforts in the Hydrogen Blending Impacts Study ("Study"). The Study concludes that "blending hydrogen into the natural gas pipeline networks is an important approach toward decarbonizing the grid, lowering greenhouse gas emissions, and advancing the development of a hydrogen economy."[1] This Study is important in transitioning to a hydrogen future for California and outlines necessary future steps that need to be taken. In our comments, the Joint Parties urge the Commission to consider implementing a hydrogen blending standard at concentrations equal to or below 5% by volume and execute several key activities to expedite the blending standard development.

II. COMMENTS ON THE RULING

1) ***DOES THE UC RIVERSIDE STUDY PROVIDE ENOUGH INFORMATION FOR THE COMMISSION TO CONSIDER ADOPTING A SAFE INJECTION STANDARD FOR HYDROGEN IN THE COMMON CARRIER PIPELINE SYSTEM?***

[1]See: 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. See p. 4.

The findings presented in the UC Riverside Study demonstrate that hydrogen blends can be safely employed on the existing natural gas grid at blend fractions below 5%, with further assessment needed to determine what level above 5% can be accommodated. These findings help clear the way for the use of hydrogen in the California natural gas grid to accelerate the transition toward a sustainable future and help achieve the State's climate and air quality goals. Based on the findings of the UCR Study, there is no basis for further delay in establishing a system-wide hydrogen blend limit at 5%. The report finds that the implementation of hydrogen blending into the gas grid at levels above 5% must be done in stages to address all R&D, technical, and management issues associated with this transition. Although many aspects of hydrogen blending have been modeled and studied in laboratory settings, the study finds that there is a lack of information from real-world operating conditions and real components rather than laboratory scale setups. For this reason, we strongly support the statement that demonstration projects with hydrogen blends between 5-20% by volume are of paramount importance in the short-term to ensure the deployment and scale-up of related technologies in the next decade. Such field validation should be pursued as expeditiously as feasible and should take full advantage of relevant field testing and validation that has been accomplished internationally such as the Leeds University hydrogen blending demonstration and the various other hydrogen blending tests done in the United Kingdom and elsewhere.

The Study addresses most aspects related to hydrogen blending, including safety, material degradation, and leakage rates. The study notes that components testing and R&D efforts are needed for hydrogen concentrations approaching a volume fraction of 20% and, in the long-term, above a volume fraction of 50%. The Joint Parties believe the Study fully addresses all safety and operational issues or concerns associated with hydrogen-natural gas blends equal to or below 5% by volume in both transmission and distribution grids. The leakage rate, material degradation, and mechanical properties of steel and polymeric materials are not expected to be impacted within this operating range. Supporting information is reported in the Study and cited from many large-scale demonstration projects in Europe, which have found an acceptable level of hydrogen injection at a volume fraction of 10%. For this reason, the Joint Parties suggest that a hydrogen injection standard should be set at a volume fraction of 5%, with the option to be reviewed every three years to incorporate the lessons learned from demonstration projects. The hydrogen partial pressure should be measured in the location of the grid subjected to the highest concentration of hydrogen, considering the distributed nature of the local injection and withdrawal locations.

The Joint Parties agree with the finding that there is not adequate information at this juncture for the Commission to justify the adoption of a safe maximum injection standard for hydrogen at concentrations above a volume fraction of 5%. However, the Study does provide the Commission with enough information on the necessary next steps to develop such a standard. We believe the Study is correct in suggesting that additional work needs to be carefully planned and conducted in stages to address the effect of hydrogen on materials, components, and equipment. Taking an expeditious yet staged approach will advance safety, promote a set of lessons learned, and lead to an injection standard that is correctly developed.

While we believe the Study outlines a clear, well-articulated pathway to develop such a standard, we disagree with the timeline set forth. The main issue with the proposed timeline is the delay in real-world, large-scale demonstrations. The Joint Parties believe that the timeline recommended should encourage real-world, large-scale demonstrations ***immediately***. If planned and executed efficiently and effectively, we can have the necessary knowledge needed to set a hydrogen blending standard at concentrations above a volume fraction of 5%. This can accelerate the transition towards the use of clean hydrogen as a fuel and energy storage medium and help keep the state on track to meet several climate and air quality goals.

As Parties to this proceeding recall, on November 20, 2020, SoCalGas, SDG&E, PG&E, and Southwest Gas (collectively, the "Joint Utilities") submitted an application[2] to implement a hydrogen blending demonstration program to develop and implement a hydrogen injection standard. This application, which is very similar to what UCR recommends as a crucial step today, set out to answer critical technical, operational, and safety questions to determine the future hydrogen blending injection standard. While this application was ultimately not approved, it aimed to help validate literature and research regarding material compatibility with a hydrogen and natural gas blend.

[2] See Joint Utilities application: https://www.socalgas.com/regulatory/a20-11-004

Targeted, real-world testing under controlled conditions is an important next logical step in developing such a standard at concentrations above a volume fraction of 5%. Therefore, we submit that the Commission should move quickly to approve a utility hydrogen blending demonstration program to inform the development and implementation of a hydrogen injection standard at higher concentrations above a volume fraction of 5%. The utilities are in the best position to begin filling in the knowledge gaps in several areas - including those that cannot be addressed through modeling or laboratory-scale experimental work - by conducting real-world demonstrations of hydrogen blending under safe and controlled conditions. This program must include a detailed timeline on how the utilities plan to scale their pilots to end-user programs, share research findings on an interim basis, provide recommendations on proper measuring and monitoring of leakage and losses, and establish a data-driven blending threshold to inform a statewide standard at concentrations above a volume fraction of 5%. The Joint Parties also request that the Commission expedite the approval process to begin the needed research. We believe it is prudent to reduce the timeline and expedite a Joint Utility Application due to the delays in this proceeding, specifically the 11-month delay in the UCR report.[3]

If California is serious about using renewable hydrogen to support the <u>decarbonization</u> of existing and new gas infrastructure, it will require material progress now. We cannot endure long regulatory and research delays, which hinder our progress in achieving our climate goals. Thus, we ask that the Commission issue an order no later than November 30, 2022, directing that the utilities begin testing real-world demonstrations no later than February 28, 2023, and provide a recommendation for a hydrogen injection standard threshold at the maximum volume fraction found to be safe and operationally feasible no later than January 31, 2024, and, by the same date, establish a program to address issues limiting the volume fraction. However, we reiterate that there is no reason for the delay in adopting a blend limit of 5% by volume.

2) ***<u>ARE THERE LEAKAGE-RELATED CONSIDERATIONS THAT THE COMMISSION SHOULD CONSIDER?</u>***

We agree with the Study and echo the importance of safety and understanding the leakage rate mechanisms from all components and materials in the gas grid. Although hydrogen diffuses in

[3] The UCR report was expected to be completed in September 2021. See: https://www.cert.ucr.edu/hydrogen-impacts-study

solids more rapidly than methane, the Study correctly finds that diffusion-based leakage is extremely small. The Study also finds that hydrogen in hydrogen-methane blends does not leak preferentially for pneumatic (pressure-driven) leaks such as those from cracks, joints, and fittings. The literature is inconsistent on whether increasing the hydrogen volume fraction also increases the leakage rate of the blended gas. Increasing the hydrogen fraction changes the gas properties of the blend such that leakage increases somewhat as the hydrogen fraction increases when the leak is through an orifice large enough to be in the continuum flow regime. In more tortuous paths, the leakage rate has been found to be unimpacted by hydrogen volume fraction. In any case, experienced leak rates on the California natural gas system are well below a volume fraction of 0.2%, and the addition of hydrogen blends in the range of a volume fraction of 5% to 20% would not appreciably change this.

These considerations support the Joint Parties' statement above that real-world demonstrations are needed to understand leak conditions from real infrastructure and components with high hydrogen concentrations. From the scientific literature, and from our own research, we believe that a standard equal to or below a volume fraction of 5% of hydrogen-natural gas blend would not create preferentially leaky joints or components in the current grid.

3) ARE THERE HEATING VALUE-RELATED CONSIDERATIONS THAT THE COMMISSION SHOULD CONSIDER?

Like biomethane, hydrogen blends will have a lower heating value than pure methane. The impact of blending on heating value will need to be addressed in setting the blend limit and in calculating the amount of energy delivered to customers for billing purposes. The gas system currently has many "heating districts" with differing heating values and have established mechanisms in place for converting measured volumes delivered to the customer to energy quantities for billing purposes. The effect will be small at the initial anticipated blend limit and can be accommodated operationally by adjusting flow conditions at higher blend levels. To illustrate, assuming that a volume fraction of 5% of hydrogen is injected into a low-pressure natural gas grid (3 bar), the volumetric heating value will reduce by approximately 3.5%, compared to 100% methane. This change is well within the range of variation in heating value on the gas system today (970 – 1160 Btu/scf), which could be compensated by changing pipeline flow rates, exploiting the reserve capacity of pipelines to carry more flow. Alternatively, a higher pipe pressure should be used to maintain the same volumetric heating rate of 100% methane. For the simple example proposed, the pressure should increase from 3 bar to 3.11 bar (3.7% increase) to maintain the same volumetric lower heating value (kJ/m3) for a mixture of 5% hydrogen-methane, compared to the 100% methane scenario. This pressure variation is considered acceptable and manageable by the distribution grid infrastructure.

At the same time, the carbon intensity (i.e., equivalent CO2 emissions) will decrease by about 0.7% and the gravimetric lower heating value of the mixture will increase by 0.92%. This would give the possibility of carrying an additional 460 kJ of energy per kilogram of gas mixture. When producing additional energy via water electrolysis using new renewable expansion capacity on the electric grid, would allow storing and transporting of approximately 765 kJ/kg of renewable electricity. For typical natural gas pipeline flow rates, this would correspond to storing and transporting MW-scale renewable electricity projects. We believe that allowing blends equal to or below a volume fraction of 5% of hydrogen into the natural gas grid is the only way to start supporting the renewable capacity expansion goals of the electricity network, with a minimum management change for the gas grid, but with a massive energy systems and emissions reduction impact.

4) *SHOULD THERE BE LIMITATIONS SET ON WHEN, WHERE, AND/OR HOW MUCH HYDROGEN CAN BE BLENDED INTO THE NATURAL GAS SYSTEM?*

Areas of High Potential Value

Enabling the injection of hydrogen at the transmission level at the maximum blend fraction that is safe and operationally feasible is critical to maximizing the value and minimizing the cost of hydrogen on the natural gas grid. The 5% standard recommended here should only be an initial limit pending additional assessment and validation of a “final” standard. The UCR Study finds that 99.6% of materials in the California transmission grid are externally coated steel pipes with cathodic protection. The main concern related to cathodically protected components is hydrogen embrittlement. The high consistency of material means that focused testing on isolated pipe segments can rapidly address this and other issues for the entire system. Similarly, an accelerated test and validation program to establish a maximum blend fraction that is tolerable for geological storage in depleted oil and gas reservoirs should be carried out.

It is critically important to fully address the impact of blend fractions above 5% on the transmission and storage level of the system because the transmission level will be the most economic part of the system for hydrogen injection. This is because of the ability to develop larger electrolysis and injection systems near large renewable resources, which creates economies of scale and reduces the cost of input power. For identified outstanding technical issues, safe injection levels should be established provisionally through analysis and testing of specimen components taken from field service (e.g., transmission pipe segment in service for 30+ years). In-service validation should be conducted on isolated sections of the system where supplemental monitoring and control can be applied during an accelerated validation period in advance of increasing the system-wide blend limit.

Because of the immense positive impact that underground hydrogen storage ("UHS") would have on the capacity expansion plan of the electric infrastructure, we believe that UHS should be demonstrated at scale. The scientific literature is still expanding on this topic, and the geological, biological, and chemical interactions of hydrogen with the surrounding underground environment are being studied. However, there is an urgent need to perform studies in real-world environments to allow for a realistic representation of the operating conditions of the storage facilities.

Difficult-to-Decarbonize Sectors

While not neglecting the full spectrum of end-uses that would potentially receive hydrogen blends, the Commission should also require the utilities to target and prioritize their efforts in blending hydrogen into the natural gas system for those hard-to-electrify sectors (*e.g., clean firm dispatchable power generation, long-haul trucking, air- and seaports, and industry*) that require an alternative to electrification since these sectors are no-regret applications; because these sectors will require cleaner fuels, investing and prioritizing now is the most logical pathway with the greatest environmental and cost benefits.

Prioritizing these sectors will require the Commission to develop a plan regarding how networks will evolve safely in line with the State's climate goals. This will help the Commission address the many decisions about hydrogen and natural gas infrastructure investments. In future years, a California hydrogen energy pipeline network will be needed to serve power generation, long-haul trucking corridors, air- and seaports, and connect industrial hydrogen demand with supply. Substantial hydrogen volumes will be required to support this pipeline. As demand for green hydrogen grows, it will displace demand that would otherwise be served by fossil fuels – liquid and gaseous. A logical transition would be to retrofit or replace existing natural gas pipelines with 100% renewable hydrogen pipeline transport over time. This hydrogen network will enable more rapid scaling of hydrogen producers, who are more likely to build scaled systems where the capability exists to transport hydrogen at scale to the broadest, most synergistic set of end-users.

The Joint Parties believe that this plan can be completed in conjunction with large-scale utility demonstrations to reduce time delays and increase regulatory efficiency. We believe the Commission – in consultation with the California Energy Commission ("CEC"), Joint Utilities, and Stakeholders – can develop a vision for dedicated hydrogen pipeline infrastructure and repurposed hydrogen blended natural gas pipelines for those hard-to-electrify sectors as well as identify those areas of the grid that can be deprioritized for hydrogen blending and injection. This work can mirror the work being done through the European Hydrogen Backbone ("EHB") Initiative, which aims to accelerate Europe's decarbonization journey by defining the critical role of hydrogen infrastructure – based on existing and new pipelines.[4] This will help set California's vision for the future of gas infrastructure and will reduce stranded asset risk and unnecessary ratepayer costs.

The Joint Parties submit that the Commission should develop a forward-looking gas pipeline infrastructure strategy that prioritizes introducing hydrogen into hard-to-electrify sectors. This plan should be completed on or before the proposed date of the Joint Utility recommendation for a hydrogen injection standard threshold at concentrations above a volume fraction of 5% (e.g., January 31, 2024).

5) ARE THERE PARTICULAR TYPES OF CUSTOMERS THAT SHOULD NEVER BE DELIVERED NATURAL GAS THAT HAS BEEN BLENDED WITH HYDROGEN?

UCI analysis of conventional residential (e.g., stovetop burners, home water heaters, and boilers) and commercial/industrial (e.g., gas turbine injectors and burners, internal combustion engines injectors) appliances show that very slight or no modifications are needed to allow for

[4] See: https://ehb.eu/

hydrogen-natural gas blends below a volume fraction of 5%.[5, 6] Therefore, the Joint Parties suggest that a hydrogen injection standard at a blend limit of 5% by volume can be established without negative consequences.

6) ***WHAT EXISTING RULES AND/OR TARIFFS NEED TO BE MODIFIED TO ALLOW HYDROGEN TO BE BLENDED INTO NATURAL GAS?***

Different hydrogen sources should be distinguished depending on their carbon intensity (kg CO2e/ kg H2). However, from a safety, material compatibility, and pipeline maintenance perspective, no difference should be made between renewable hydrogen from water electrolysis, hydrogen naturally present in biomethane, and fossil fuel-based hydrogen.

Regarding tariffs, the tariffs governing gas quality standards will need to be modified to specify a new upper limit on hydrogen volume, which should initially be established at or near a volume fraction of 5%. In addition, the Standard Renewable Gas Interconnection Tariff ("SRGI Tariff") will likely require modifications such as, but not limited to:

- Formal inclusion of renewable hydrogen as an eligible fuel under the tariff
- A definition of renewable hydrogen
- Modifications to the interconnection protocols and agreements, including specification of the extent to which on-system mixing (i.e., dilution of injected hydrogen with system gas) is permitted in determining compliance with the blend limit
- Supplemental rules governing cost accounting and recovery for hydrogen-related expenditures

7) ***IS THERE A NEED FOR ADDITIONAL TESTING ON ONE OR MORE GAS UTILITY'S PIPELINE SYSTEMS BEFORE HYDROGEN IS ALLOWED TO BE BLENDED INTO NATURAL GAS?***

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[5] Colorado, Andres; McDonell, Vincent. (University of California Irvine, Combustion Laboratory). 2016. Effect of Variable Fuel Composition on Emissions and Lean Blowoff Stability Limits. California Energy Commission. Publication number: CEC-500-2017- 026.

[6] McDonell, Vincent, Yan Zhao, and Shiny Choudhury (University of California Irvine, Combustion Laboratory). 2020. Implications of Increased Renewable Natural Gas on Appliance Emissions and Stability. California Energy Commission. Publication Number: CEC-500-2020-070.

Testing on gas utilities' pipeline systems should be performed as part of demonstration projects for concentrations of hydrogen between a volume fraction of 5-20%. For concentrations lower than a volume fraction of 5%, a blend limit can be established without further delay, and a monitoring and validation program should be established to confirm performance to expectations and inform future increases in the blend limit.

8) ***IS THERE A NEED TO WEIGH ANY COST-RELATED OR ENVIRONMENTAL-RELATED CONSIDERATIONS AT THIS TIME IF THE COMMISSION DOES NOT YET INTEND TO MANDATE A LEVEL OF HYDROGEN PROCUREMENT? IF SO, WHAT ARE THOSE CONSIDERATIONS?***

The Joint parties believe that the environmental benefits of renewable hydrogen are well established, and that qualification of renewable hydrogen for all renewable gas programs should be established without delay. As with all utility programs and activities, the Commission should ensure that costs borne by ratepayers are just and reasonable. This is best done by establishing a procurement program without further delay.

The Joint Parties believe that the Commission can weigh in on any cost-related or environmental-related considerations as renewable hydrogen programs are implemented. The upgrade or installation of hydrogen-related pipelines during the next decade will require progress on a wide range of issues now, rather than a linear series of sequential regulatory discussions that could further delay the effective transition to a renewable hydrogen economy. For this reason, the Joint Parties ask the Commission to release a new Ruling discussing cost and environmental-related questions in conjunction with the large-scale utility demonstrations to reduce future delays, once a standard is in place. This regulatory effort should be well-vetted, subject to initial and reply comments, and understood on or before the proposed date of the Joint Utility recommendation for a hydrogen injection standard threshold at concentrations above a volume fraction of 5% (e.g., January 31, 2024).

If the Commission fails to mandate a level of hydrogen injection, the main cost incurred would be associated with the capacity expansion cost of the electricity grid needed to support the installation of a large amount of renewable electricity generation. As demonstrated previously, a small amount of hydrogen in the existing natural gas grid would be able to store and transport massive amounts of renewable electricity, with minimum efforts for the monitoring and change in the maintenance schedule of the network. Moreover, with the increased penetration of fluctuating renewable electricity sources, the chances of blackouts and grid instability will increase. The costs associated with the disruption of economic activities are incalculable.

9) WHAT DEFINITION SHOULD THE COMMISSION USE FOR "RENEWABLE" HYDROGEN? IF YOU PREVIOUSLY RECOMMENDED A DEFINITION FOR "RENEWABLE" HYDROGEN IN COMMENTS FILED IN A.20-11-004, PLEASE EITHER RESTATE THAT RECOMMENDATION OR PROVIDE AN UPDATED RECOMMENDATION.

The Joint Parties propose that the Commission defines "renewable hydrogen" to mean hydrogen where all energy inputs and feedstock used in the production and delivery of the hydrogen are consistent with the California Renewables Portfolio Standard Program (Article 16 (commencing with Section 399.11) of Chapter 2.3). Any electricity used shall be from an eligible renewable energy resource, as defined in Section 399.12. Any nonelectric energy input or feedstock shall be from a source included in paragraph (1) of subdivision (a) of Section 25741 of the Public Resources Code.

III. CONCLUSION

The Joint Parties appreciate the opportunity to submit these comments and look forward to collaboration with the Commission and stakeholders on this initiative.

Respectfully submitted,

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