September 19, 2023

RE: CEERT's Comments on the California Air Resources Board SB 1075: Report on Hydrogen Deployment, Development, and Use

SB 1075 directs CARB, in consultation with CEC and California Public Utilities Commission ("CPUC"), to provide an evaluation to the public (to be posted on CARB's website) by June 1, 2024, including policy recommendations pertaining to the development, deployment, and use of hydrogen. The bill also directs the CEC to study and model potential growth for hydrogen in decarbonizing the electrical and transportation sectors of the economy in the 2023 and 2025 editions of its Integrated Energy Policy Report (IEPR). It directs the CPUC, CEC, and CARB to consider green electrolytic hydrogen an eligible form of energy storage, and to consider other potential uses of green electrolytic hydrogen. Some of the other uses that have been considered are hydrogen blending in natural gas, carbon capture in conjunction with production of non-electrolytic hydrogen, and hydrogen combustion. These three methods have been proposed by various stakeholders as a way to integrate hydrogen and minimize emissions. However, CEERT has concerns about these three methods.

Blending Hydrogen into Natural Gas Pipelines

In 2021, the U.S. natural gas infrastructure provided service for 32% of the nation's energy consumption. Blending hydrogen with natural gas has been increasingly looked at as a alternative to natural gas.

In a Hydrogen Blending Impacts Study done by the University of California, Riverside, it was found that hydrogen blends above 20% "present a likelihood of permeating plastic pipes, which can increase the risk of gas ignition outside the pipeline."[1] The study also found that select metals and alloys used in national gas transmission systems that were exposed to hydrogen through electrochemical charging showed characteristics of hydrogen embrittlement, thus affecting their strength and toughness. Furthermore, it found that blends above 5% could require modifications of appliances such as stoves and water heaters to avoid leaks and equipment malfunction. The presence of hydrogen in the natural gas pipeline networks negatively impacts steel's mechanical properties and several studies have established that crack growth rates substantially increase in the presence of hydrogen. Hydrogen is the smallest molecule causing it to leak easily and difficult to detect, increasing risk of leak ignition. Hydrogen itself is not a greenhouse gas but acts as one indirectly. Hydrogen can lead to increased NOx which can cause damage to the human respiratory tract and increase a person's vulnerability to, and the severity of, respiratory infections and asthma. CEERT believes additional research, looking at the impacts of hydrogen blending on the structural integrity of pipes and building appliances is necessary before considering hydrogen blending as an alternative to natural gas.

[1] Raju, Arun Sk, et al. *Hydrogen Blending Impacts Study*. 18 July 2022. https://www.cert.ucr.edu/hydrogen-impacts-study

Carbon Capture Systems (CCS) with Hydrogen

The use of carbon capture technology has been proposed for the manufacturing of hydrogen from natural gas. Over 90% of hydrogen produced today is made from coal or natural gas, with the resulting carbon dioxide released into the atmosphere. While being completely carbon-free, electrolytic hydrogen is the most ideal method for reaching clean energy goals, and CEERT believes that hydrogen manufactured from coal or natural gas paired with CCS should be discouraged.

Natural gas production is often accompanied by methane leaks and stored carbon can leak out from its underground storage location. In January 2022, the organization Global Witness published a report that found that the Shell Oil Alberta-based Quest project that began in July 2020 only captured 48% of the CO2 being produced (just 39% with the fuel stock's life-cycle emissions considered).[2] Achieving higher capture rates requires substantially higher amounts of energy with corresponding costs and environmental impacts. Hydrogen produced from natural gas with CCS may only have 9 to 12% lower emissions than hydrogen produced from natural gas without CCS. Hydrogen made from natural gas, even when paired with CCS, has higher emission rates than burning natural gas alone. A recent Institute for Energy Economics and Financial Analysis study of 13 major carbon capture and utilization and storage projects (CCUS) found that 10 of those projects either underperformed or failed to reduce emissions according to

[2] Global Witness. *Hydrogen's Hidden Emissions*. 20 Jan. 2022. https://www.globalwitness.org/en/campaigns/fossil-gas/shell-hydrogen-true-emissions/

their designed capacities, often by a considerable margin.[3] It also found that using carbon capture to extend the life of fossil fuel power plants is a significant financial and technical risk. The majority of projects using CCS has been for enhanced oil recovery which consequently has led to more emissions. Only about 10-20% of CCS projects have successfully stored carbon in dedicated geological structures without using it for enhanced oil. CCS is an uncertain technology and CEERT believes it should not be relied on for capturing emissions.

<u>Hydrogen Burning in Turbines</u>

Gas turbines (GTs) are broadly employed for electricity generation due to their ability to produce high power in compact space, start quickly, and their potential for integration with other power generation. Up until recently, fossil fuels such as oil and gas were primarily used for combustion. Hydrogen is now being proposed as a "renewable" alternative turbine fuel. However, the combustion of hydrogen increases rates of NOx formation.

A recent industry report from the European Turbine Network regarding hydrogen combustion stated that, "the higher adiabatic flame temperature of H2 will result in higher NOx emissions if no additional measures are undertaken", furthering that, "it will be particularly a challenge to achieve even stricter NOx-limits foreseen in the future."[4] The Union of Concerned Scientists (UCS) also cited that "when hydrogen is combusted (as opposed to use in a fuel cell),

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[3] Robertson, Bruce , and Milad Mousavian. *The Carbon Capture Crux*. Institute for Energy Economics and Financial Analysis, Sept. 2022. https://ieefa.org/resources/carbon-capture-crux-lessons-learned

[4] ETN Hydrogen Working Group., and Peter Kutne. *THE PATH towards a ZERO-CARBON GAS TURBINE HYDROGEN GAS TURBINES* https://etn.global/wp-content/uploads/2020/01/ETN-Hydrogen-Gas-Turbines-report.*pdf*

it can generate significant NOx emissions, commensurate with that of natural gas combustion—or worse."[5] Even Mitsubishi, the developer of a new plant in Utah that will blend 30% hydrogen with 70% natural gas, said in a report that the mixture will produce NOx and carbon emissions "equivalent to those from modern natural gas plants."[6] Most gas turbines today are dry low NOx combustion systems specifically designed to limit the amount of NOx released by burning natural gas or methane, meaning that these turbines can handle a low amount of hydrogen but due to the fundamental differences between hydrogen and methane, they are not designed to handle larger concentrations of hydrogen. A recent engineering review of domestic boilers with potential to run on hydrogen concluded that without individual testing, it was difficult to predict the resulting NOx emissions due to the uncertainty in the effect of hydrogen on flame temperature.[7] A report from Environmental Science found that the adoption of hydrogen as a combustion fuel, if applied using only existing appliance emissions regulations, would not deliver optimal air quality benefits.[8] CEERT recognizes the potential of manageable concentrations of hydrogen blending for use in GTs to cut emissions in the near term, but

[5] McNamara, Julie. "What's the Role of Hydrogen in the Clean Energy Transition?" *Union of Concerned Scientists*, 9 Dec. 2020, https://blog.ucsusa.org/julie-mcnamara/whats-the-role-of-hydrogen-in-the-clean-energy-transition/.

[6] Mitsubishi Heavy Industries Group. "Renewable Energy Storage: Combining Existing Dry Low NOx Combustion Technology with Proven Hydrogen Storage and Production Approaches." 2020. https://www.changeinpower.com/wp-content/uploads/2020/03/MHPS-ACES-Proven-Technology.pdf *Note: This link connects to the March 2020 version of this report. A subsequent version published in July 2020 removed all mentions of CO2 emissions from the report without additional explanation. Both versions of the report can be found online as of December 22, 2020.*

[7] Wright, Madeleine L., and Alastair C. Lewis. "Emissions of NO*X* from Blending of Hydrogen and Natural Gas in Space Heating Boilers." *Elementa: Science of the Anthropocene*, vol. 10, no. 1, 2021, https://doi.org/10.1525/elementa.2021.00114. Accessed 6 Dec. 2022.

[8] Aggarwal, Aman, et al. "Study of Utilization of Hydrogen as Fuel in Internal Combustion Engine." *Materials Today: Proceedings*, vol. 64, 2022, pp. 1211–1216, https://doi.org/10.1016/j.matpr.2022.03.660.

encourages utilizing other clean, renewable energy resources in place of any combustion as California approaches its SB 100 energy goals.

On August 16th, 2022, President Biden signed the Inflation Reduction Act into law, with the creation of ARCHES, California's public-private hydrogen hub consortium to accelerate the development and deployment of clean, renewable hydrogen projects and infrastructure and the most recent application for the Department of Energy's Hydrogen Hub. CEERT believes that the use of CCS in non-electrolytic hydrogen production should not be considered, and that additional research for hydrogen blending and combustion be conducted before incentivization and large-scale deployment in order to minimize the risks of leakage and NOx formation. We thank the Board for your time in reading our comments and look forward to continued efforts on a safe, clean hydrogen deployment.

Sincerely,

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