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Electrochaea Comment on Clean Hydrogen Program

Additional submitted attachment is included below.

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December 16, 2022

Submitted via https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=22-ERDD-03

The Honorable Siva Gunda, Vice Chair
California Energy Commission
1516 Ninth Street
Sacramento, California 95814

Re: Clean Hydrogen Program Docket No. 22-ERDD-03

Dear Vice Chair Gunda:

Electrochaea Corporation (Electrochaea) appreciates the opportunity to submit comments on the proposed Clean Hydrogen Program, created in Assembly Bill 209, presented in the staff workshop on Dec. 1, 2022. Electrochaea is supportive of the goal of the program to "accelerate clean hydrogen production and use" and recommends that the approach to achieving this goal supports multiple means of clean hydrogen production and multiple uses without specifying particular technologies. Relying on the market to identify the technologies with the most promise is the best way to achieve a sustainable hydrogen production market for the California energy transition.

Electrochaea is the provider of an industrial-scale technology for the production of grid-quality renewable methane, which can replace any use of fossil natural gas. Using our power-to-gas biomethanation technology, clean hydrogen and CO_2 are combined by a microorganism, an archaea, to produce renewable synthetic methane. Synthetic methane production is an end-use of clean hydrogen ready for industrial implementation. Renewable synthetic methane, like renewable natural gas (RNG), can replace geologic natural gas to contribute to California's transition to a clean energy economy by significantly reducing GHG emissions, utilizing the existing gas distribution and storage infrastructure, storing renewable energy for later use, and greening the natural gas grid.

I. Production of synthetic fuels using clean hydrogen is ready for widescale end use.

In this comment, Electrochaea would like to highlight synthetic fuel production as one of the important end uses of clean hydrogen. Multiple types of clean hydrogen end-users are essential

to sustain and grow the hydrogen market[1], which has significant benefits including storage of clean hydrogen using established means of distribution.

Power-to-gas methanation is an innovative hydrogen utilization technology that is ready for deployment. Electrochaea's industrial-scale power-to-gas biomethanation technology produces grid-quality renewable synthetic methane, a replacement for all uses of fossil natural gas, using clean hydrogen and carbon dioxide (CO_2). Clean hydrogen can be used from any source that delivers hydrogen with a qualified carbon intensity (CI). The CO_2 feedstock can come from raw biogas or CO_2 that has been captured and purified from other sources. When clean synthetic methane is used, the extraction and combustion of fossil natural gas are avoided. Analogous to the greening of the power grid by solar and wind, energy delivered in the gas grid is becoming decarbonized as the percentage of RNG and renewable synthetic methane is increased in the gas infrastructure.

Storage of clean hydrogen in synthetic methane. Hydrogen is more difficult and expensive to store and transport than natural gas. Instead of storing hydrogen directly, hydrogen can be used to produce synthetic methane, a natural gas replacement, which can be easily stored and transported in the existing gas infrastructure. The production of methane from hydrogen, in a process called methanation, is an efficient means to store the energy contained in the hydrogen molecule. "The combustion of 4 H_2 with 2 O_2 to 4 H_2O yields 949 kJ mol^{-1} and that of CH_4 with 2 O_2 to CO_2 and 2 H_2O yields 818 kJ mol^{-1} free energy. Thus, most of the combustion energy of H_2 is conserved in methane."[2]

Enabling long-duration energy storage. Unlike traditional batteries, clean, synthetic methane produced using a power-to-gas process provides long-duration energy storage and can play a significant role in addressing the seasonal mismatch in supply and demand that makes it difficult to achieve 100% renewable electricity[3]. Analogous in many ways to pumped hydro or other forms of gravity-based storage, Electrochaea's technology converts any power generated in excess of immediate demand into synthetic methane for much later use. In this way, the existing gas grid and connected storage facilities become the largest battery in the US, storing renewable energy for use later in the day, month, or even year. The US has the design capacity to store ~4,690 billion cubic feet of natural gas[4], which is equivalent to 1.37 billion MW. ~6,000 MW of battery storage capacity was planned for 2021[5]. Thus, there is as much as 23,000 times

[1] In the 2021 tracking report from the International Energy Agency on hydrogen, it is concluded that "demand growth in new sectors (e.g. for some transport and industrial applications, production of synthetic fuels and electricity storage)," will drive the expansion of the clean hydrogen market.
https://www.iea.org/reports/hydrogen

[2] *Thauer et al. 2010. Hydrogenases from Methanogenic Archaea, Nickel, a Novel Cofactor and H_2 Storage. Annual Review of Biochemistry 77:509-536*

[3] Denholm et al. 2021. The challenges of achieving a 100% renewable electricity system in the United States. Joule 5: 1331-1352

[4] https://www.eia.gov/todayinenergy/detail.php?id=30632

[5] https://www.eia.gov/todayinenergy/detail.php?id=49236

the amount of storage in the natural gas infrastructure as in the 2021 battery storage capabilities.

Distribution of "stored hydrogen" within the natural gas grid. Instead of constructing hydrogen-specific pipelines or devising means to transport liquid hydrogen, stored hydrogen in the form of synthetic methane can be distributed in the existing natural gas infrastructure.

II. General comments on the proposed Clean Hydrogen Program

The separation of the Clean Hydrogen Production Program into large and distributed production groups may not be the most effective means to support the hydrogen production industry. Given that the goal of hydrogen production is to support the State's goals for GHG reduction by 2045, it is more appropriate to let projects that have support from industry set the hydrogen production goals and locations of the projects. The production goals and locations would be determined by the specific needs of the individual projects. In addition, the CEC should not prioritize specific technologies but should maintain a technology-agnostic approach and support projects with the greatest potential to achieve the State's goals. Limiting applicants by technology, production goals and location will stifle the creation of innovative and economically feasible projects.

Problems with distribution related to the physical properties of hydrogen and the extra expense and GHG emissions that occur with the transport and distribution of hydrogen are impetus enough to promote creative approaches to these problems. An example that applies to projects that use hydrogen as a feedstock to produce synthetic methane highlights that co-localization of hydrogen production and CO_2 capture is ideal. In California, animal or organic waste anaerobic digestion facilities and landfill sites are locations for hydrogen end-use to produce synthetic methane. A power-to-gas biomethanation project will support the hydrogen market with a new end-use, store renewable electricity for future use, and provide an additional source of clean methane to replace fossil gas. At biogas sites, synthetic methane production can nearly double the amount of clean methane produced. Projects that can be commercialized, with the help of California as administered by the CEC, should be supported without unnecessary restrictions about project location or the volume of hydrogen produced per day.

III. Comments related to the presentation of Dec. 1, 2022

Suggested changes to the hydrogen supply chain diagram. In the Hydrogen Supply Chain Slide shown at the workshop, (Figure 1), fuels that could be used as hydrogen carriers are shown under the titles Conversion and Applications. Electrochaea agrees that using another molecule to carry the energy in the hydrogen molecule is a sensible means to facilitate the transmission and distribution of the energy present in the feedstock. The diagram in the slide should include the gaseous hydrogen carrier, methane, which can be compressed and distributed in the existing gas infrastructure. The production of methane from hydrogen, in a process called

methanation, is an efficient means to store hydrogen and the energy contained in the hydrogen molecule.

Synthetic methane can also be included as a fuel in the final box under Applications. The term "Syngas-based Synthesis" is confusing as it is not a comprehensive term for all types of fuels and chemicals that could be synthesized using hydrogen as a feedstock. A better term would be "synthetic fuel".

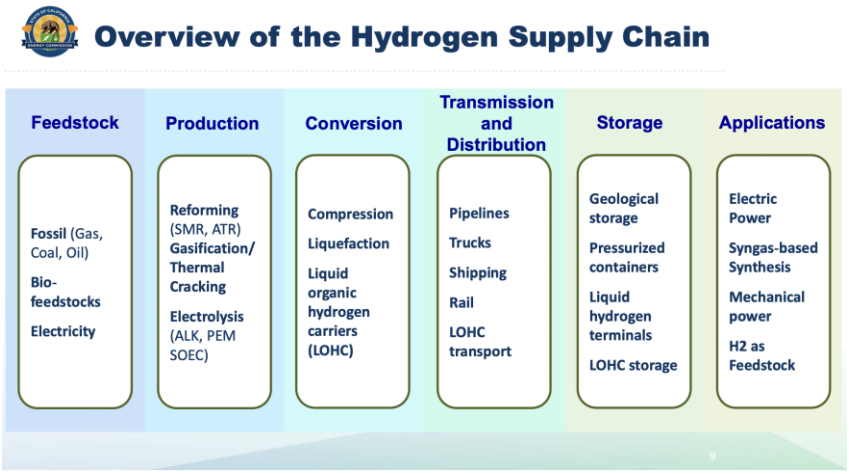

Figure 1. Slide shown at the Staff Workshop on Dec. 1, 2022.

Water use efficiency. Water is produced during the power-to-gas methanation process (Figure 2). For every metric ton of hydrogen input into the reactor that is used for methane production, ~1,200 gallons (4,500 kg) of water are produced. This water must be removed from the reactor, and thus it can be cleaned up and used to supply an electrolyzer or it can be returned to the water table.

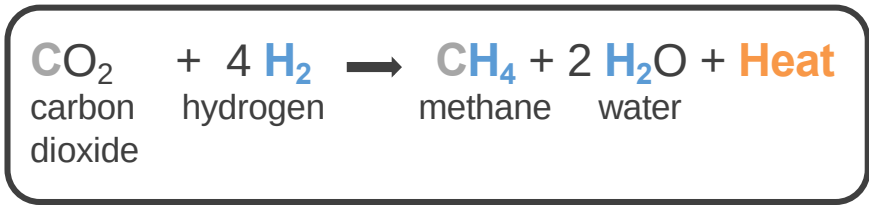

Figure 2. The methanation process combines 4 hydrogen molecules and 1 carbon dioxide molecule to produce 1 methane molecule and 2 molecules of water.

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Electrochaea is actively exploring projects to serve the California market and believes that our biomethanation technology can play a substantial role in meeting the climate goals of the State of California, with support and recognition of the value of the technology, and those like it, from agencies in California. Electrochaea encourages the State of California to provide goals and policies to green the gas grid. It is important to support the ability of the private sector to evaluate and commercialize technologies that deliver on the State's climate goals, with a regulatory and policy apparatus that is supportive of required investments. Thank you for your consideration of our comments.

Sincerely,

/s/ Mich Hein

Mich Hein, CEO
Electrochaea Corporation
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