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Comments on DER attached (please ignore previously submitted attachment)

Additional submitted attachment is included below.

California Hydrogen Business Council

Hydrogen Means Business in California!

Main Office: 18847 Via Sereno
Yorba Linda, CA 92886

DC Office: 1211 Connecticut Ave NW, Ste 650
Washington, DC 20036

Phone: (310) 455-6095 | Fax: (202) 223-5537
info@californiahydrogen.org | www.californiahydrogen.org

CHBC Comments on the Distributed Energy Resources (DER) Research Roadmap

October 2, 2019

The California Hydrogen Business Council (CHBC)[1] appreciates the opportunity to offer comments on the Energy Commission's workshop on Distributed Energy Resources (DER) Research Roadmap conducted on September 17, 2019. CHBC supports the Commission's efforts to develop a strategic DER Research Roadmap that would address both long-term and short-term energy system goals for California (as presented during the workshop).

Decarbonized Hydrogen's Potential as DER in California

Renewable and zero carbon hydrogen can play a critical role as a DER in California to support grid resiliency and offer ancillary services to the grid to address both long-term and short-term energy system needs. Today, renewable hydrogen produced from excess renewable electricity via electrolysis can be used as a dispatchable load-balancing resource that complements intermittent renewables, and as a flexible energy storage medium that is capable of long duration[2], which will be needed with high levels of renewable power generation. Hydrogen can be dynamically produced during peak renewable electricity production times and can be converted back into electricity through a zero emissions fuel cell when solar or wind energy are not available. In this way, hydrogen supports increased deployment of intermittent, renewable power production assets into microgrids and the utility grid network as a whole. Hydrogen is an especially valuable energy storage solution that is cheaper than battery energy storage when massive amounts of energy storage or long durations of energy storage are required, for example as required for seasonal shifting of renewable energy.

Electrolysis is a mature technology that converts electricity into hydrogen and oxygen by splitting water. Beyond the storage function of converting electricity into gaseous fuel for later use, these systems can cycle up and down rapidly providing multiple services including voltage and frequency regulation, spinning reserves, ramping services, and capacity across multiple grid domains. Similar to batteries, electrolyzers are connected to the grid via inverters which have very fast response times, allowing them to provide operational flexibility and modulate hydrogen output to provide energy management and ancillary services to the electric grid, along with participation in energy markets on the utility grid at network scale, all while producing hydrogen.

The rapid deployment of solar and wind generation has created challenges with managing the electric power system in California. The self-generation sector alone is expected to increase its generation capacity from 28,000 GWh (2019) to 52,000 GWh (2030), an increase of 85% in self-generation capacity from the current levels.[3] Utility scale renewables and doubling of energy efficiency measures in the future can further cause significant challenges to managing the over-supply of electricity on the grid during peak hours. Solar and wind production frequently

[1] The views expressed in these comments are those of the CHBC, and do not necessarily reflect the views of all of the individual CHBC member companies. Members are listed here: www.californiahydrogen.org/aboutus/chbc-members/

[2] Long duration would include anything greater than 4 hours of discharge

[3] CEC-IEPR Commissioner Workshop on 2019 Preliminary California Energy Demand Electricity and Natural Gas Demand Forecast, Self-Generation Forecast presentation, slide 10, https://ww2.energy.ca.gov/2019_energypolicy/documents/2019-08-15_workshop/2019-08-15_presentations.php

exceeds electrical demand with limited ability to store this surplus energy optimally.[4] In the absence of a comprehensive energy storage solution, the California Independent System Operator (CAISO) curtails these renewable sources, resulting in missed opportunities to utilize these valuable renewable energy resources. The excess electricity can be used to produce and store renewable hydrogen via electrolysis[5] in a cost-effective manner and can be used across multiple sectors from power generation, transportation, heating, and commercial and industrial end use applications.

In 2015, the CAISO curtailed more than 188 GWh of solar and wind generation.[6] In 2016, the curtailment rose to more than 308 GWh. In 2017, California curtailment rose again to 401 GWh of solar and wind generation. The curtailment rates have increased ever since as shown in the table below.[7]

CAISO wind and solar curtailments by year

Year	GWh
2015	188
2016	308
2017	401
2018	461
2019 (until June 1)	679

As of June 1, 2019, the renewable curtailment levels stood at a staggering 679 GWh, with an estimated 34% renewable energy penetration in California as of 2018[8]. From an energy equivalency perspective, 679 GWh of zero carbon electricity is equivalent to offsetting approximately 480,000 metric tons of CO_2e, according to the EPA's GHG equivalency estimates[9], or equivalent to producing 12.5 million kilograms of zero carbon hydrogen.[10]

As the Renewable Portfolio Standard (RPS) requirement climbs to 60%, and as retail electricity supply then grows to 100% renewable and zero carbon generation, these curtailments will continue to grow, yielding significantly less GHG emission reductions than anticipated, and potentially leaving California in a disadvantaged position paying for expensive partial solutions and over-procuring renewable electric resources with diminishing returns.[11] Integrating hydrogen produced from excess electricity is a scalable and comprehensive energy storage solution that can play a vital role in supporting the rising RPS and clean electricity target by optimizing and synchronizing California's energy resources and providing a much needed linkage between variable renewable electric resources, seasonal energy storage, and dispatchable electric generation. Enabling hydrogen technology in California will help remediate time-of-day and seasonal energy imbalances between supply of power from renewable sources and its demand. While short-term balancing of electricity can utilize technologies such as

[4] *Impacts of Renewable Energy on Grid Operations,* California Independent System Operator (May 2017), at available at https://www.caiso.com/Documents/CurtailmentFastFacts.pdf
[5] The electrolysis process uses renewable electricity to split water (H_2O) into hydrogen (H_2) and oxygen (O_2)
[6] http://www.caiso.com/informed/Pages/ManagingOversupply.aspx
[7] Data shown in the table is based on CAISO's oversupply data published as of 8/7/2019, http://www.caiso.com/informed/Pages/ManagingOversupply.aspx
[8] https://www.energy.ca.gov/sites/default/files/2019-06/renewable_highlights.pdf
[9] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
[10] Assuming 54 kWh/kg of hydrogen energy conversion ratio at 61% electrolyzer efficiency.
[11] *2025 California Demand Response Potential Study*, Lawrence Berkeley National Laboratory, 2017, http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442452698.

demand-side management and batteries, long-term storage options will be required to optimize California's electric system under an electricity portfolio increasingly made up of renewable and zero carbon generation.

Hydrogen produced from renewable sources like landfill gas, organic waste, and renewable electricity can be integrated as distributed energy resources across California to help decarbonize the natural gas grid. Blending hydrogen into the existing natural gas infrastructure can help reduce significant upfront capital costs involved in developing new transmission and distribution energy infrastructure, thus helping California meet its decarbonization goals more cost effectively.

International Efforts to Utilize Hydrogen as an Electricity System Support and Decarbonization Strategy

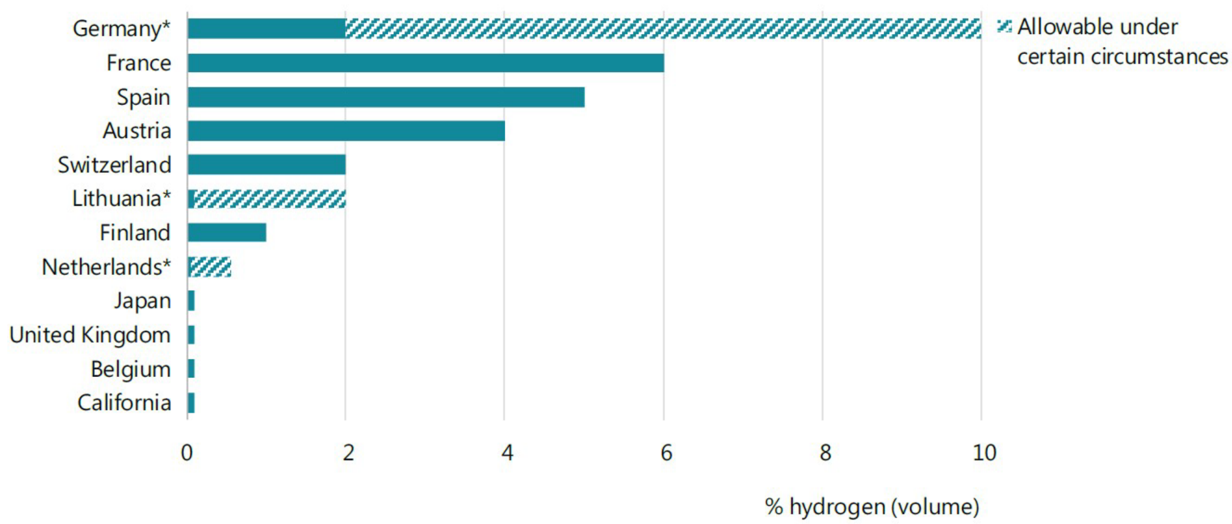
Deploying hydrogen injection into gas infrastructure is being pursued as a renewable electricity integration and decarbonization strategy around the world, with current blending protocols exceeding 10% in some areas, with limits up to 100% being explored. According to the International Energy Agency's (IEA) Future of Hydrogen Report, "there are currently 37 demonstration projects examining hydrogen blending in the gas grid. The Ameland project in the Netherlands did not find that blending hydrogen up to 30% posed any difficulties for household devices, including boilers, gas hobs and cooking appliances.[12] Injection has also been tested at both the transmission and distribution level."[13]

According to the IEA's report, many European countries including Germany, France, Spain, Austria and Switzerland have already adopted hydrogen blending protocols with blending percentages ranging from 2-10% based on end use application and other technical constraints (see Figure 1 below). The European Commission is examining the development of detailed standards and the role of renewable gas and hydrogen in the natural gas network.[14] There are also several European industry working groups (e.g. HyReady and HIPS-Net) examining standards for hydrogen blending into their natural gas grids as part of their deep decarbonization strategy. In the United Kingdom, Keele University is exploring hydrogen blending into its private gas network beginning in 2019 to reduce carbon emissions from heating buildings,[15] and the HyDeploy Project plans to blend up to 20% hydrogen as part of their decarbonization efforts.[16] In Germany, electrolytic hydrogen with the gas system as a storage resource is a fundamental part of the country's strategy to achieve greenhouse gas reduction and renewable electricity targets. A German public-private project was launched to demonstrate safe blending of 20% hydrogen into the existing pipeline, which will include testing of impacts on 400 heating systems and other customer end use devices.[17] The H21 project in the UK also recently opened a testing facility for 100% hydrogen, with a view toward examining the feasibility of converting UK gas networks entirely to hydrogen. [18]

[12] International Energy Agency. *Future of Hydrogen Report, Seizing today's opportunities.* June 2019. https://webstore.iea.org/the-future-of-hydrogen, pg. 73.
[13] International Energy Agency. Data & Publications Website. Available at: https://webstore.iea.org/the-future-of-hydrogen
[14] International Energy Agency. *Future of Hydrogen Report, Seizing today's opportunities.* June 2019. https://webstore.iea.org/the-future-of-hydrogen, pg. 73.
[15] HyDeploy Website. Available at: https://hydeploy.co.uk/
[16] Gas Power Heat Systems Network. *Trial to explore blending hydrogen gas network.* February 2018. Available at: https://networks.online/gphsn/news/1000904/trial-explore-blending-hydrogen-gas-network
[17] https://www.eon.com/en/about-us/media/press-release/2019/hydrogen-levels-in-german-gas-distribution-system-to-be-raised-to-20-percent-for-the-first-time.html
[18] https://www.northerngasnetworks.co.uk/2019/07/04/worlds-first-100-hydrogen-testing-facility-unveiled/

The Australian Gas Infrastructure Group has announced plans to blend hydrogen into its natural gas supplies to take advantage of excess renewable generation. The utility plans for Australia's first power-to-gas plant worth $8.9m to be built in Adelaide. The hydrogen produced will be injected into the local gas distribution network to provide low-carbon gas to homes and businesses.[19]

Figure 1: Current limits on hydrogen blending in natural gas networks (IEA, 2019)



* Higher limit for Germany applies if there are no CNG filling stations connected to the network; higher limit for the Netherlands applies to high-calorific gas; higher limit for Lithuania applies when pipeline pressure is greater than 16 bar pressure.

Sources: Dolci et al. (2019), "Incentives and legal barriers for Power-to-Hydrogen pathways: An international snapshot", *International Journal of Hydrogen*; HyLaw (n.d.), *Online Database*; Staffell et al. (2019) "The role of hydrogen and fuel cells in the global energy system", *Energy and Environmental Science*.

In Japan, as part of the New Energy and Industrial Technology Development Organization project, Obayashi Corporation and Kawasaki Heavy Industries, Ltd. delivered the world's first gas turbine fueled by 100% hydrogen for energy and heat generation.[20] Mitsubishi Hitachi Power Systems has successfully developed a "large-scale hydrogen gas turbine" combustor that uses a mix of liquified natural gas (LNG)—the fuel used in gas-fired thermal power—and 30% hydrogen. It burns hydrogen while allowing suppression of NOx emissions to the level of gas-fired thermal power. The technology is compatible with an output equivalent to 700 MW and it offers a reduction of about 10% in CO_2 emissions compared with GTCC."[21] Notably, Mitsubishi Hitachi Power Systems has also partnered with Magnum Development recently announced a 1,000 MW energy storage project in Utah that will deploy electrolytic hydrogen storage and hydrogen electricity generation, along with other solutions.[22]

Additionally, General Electric's (GE) "hydrogen-ready" (6B.03) turbines at the Gibraltar-San Roque Oil Refinery in Spain, have logged thousands of hours combusting a blend of hydrogen and fuel gas. The same turbines are also

[19] GTM. Australia Seeks Hydrogen to Soak Up Excess Renewable Energy Production. March 2018. Available at: https://www.greentechmedia.com/articles/read/australia-looks-to-hydrogen-to-soak-up-excess-renewable-energy-production#gs.sb4MM1M

[20] New Energy and Industrial Technology Development Organization. *World's First Heat and Electricity Supplied in an Urban Area Using 100% Hydrogen-Towards Establishing Optimal Energy Control Technology in Local Communities.* April 2018. Available at: https://www.nedo.go.jp/english/news/AA5en_100382.html

[21] Mitsubishi Hitachi Power Systems, https://www.mhps.com/special/hydrogen/article1/index.html

[22] https://www.environmentalleader.com/2019/05/energy-storage-project-utah/

in operation at a South Korean refinery, with more than 20 years combusting a fuel blend with more than 70% hydrogen and has even operated at a 90% hydrogen blend. In the U.S., a petrochemical plant in Louisiana has been producing electricity using a blend of natural gas with hydrogen with its GE 7F gas turbines.[23]

California has an excellent opportunity to learn from the work being done in other countries in integrating hydrogen into their energy value chain. Hydrogen can play a pivotal role in California as a strategic or a tactical DER resource to help achieve California's emission reduction goals. The CHBC requests the CEC to include the research needs identified by the CHBC (research needs filed separately using the research needs template) as part the ongoing DER Research Roadmap evaluation.

We appreciate the Energy Commission's consideration of these points and would be happy to explore them in detail with you.

Sincerely,

Emanuel Wagner
Deputy Director
California Hydrogen Business Council

[23] GE Reports. The Hydrogen Generation: These Gas Turbines Can Run On The Most Abundant Element In the Universe. January 2019, https://www.ge.com/reports/hydrogen-generation-gas-turbines-can-run-abundant-element-universe/