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Market Development Opportunities and Pathways for Renewable Hydrogen in California

Additional submitted attachment is included below.

CALIFORNIA HYDROGEN BUSINESS COUNCIL

Hydrogen Means Business in California!

CA 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: Market Development Opportunities and Pathways for Renewable Hydrogen in California

August 10, 2017

This document is to supplement comments previously filed by the California Hydrogen Business Council (CHBC) on Docket: 17-IEPR-07 – Integrated Resource Planning. Specifically, the CHBC seeks in this submission to provide further details regarding opportunities and potential pathways to expand market development of renewable hydrogen in California across several applications. The recommendations are intended to enhance, not replace, the policy recommendations offered in CHBC's original comments submission.

Key conclusions are that California is an optimal state to be pursing renewable hydrogen market development because:

- **there are many applications and opportunities for accelerating market expansion of renewable hydrogen in California.**

- **California, the 2nd largest consumer of hydrogen in the US, has a large and growing demand for hydrogen that must align with its climate and clean air goals.**

- **renewable hydrogen enables higher penetration of renewable electricity generation and greater degrees of electrification via renewable electricity sources by providing an important solution for avoiding curtailment of renewable electricity generation, for which California is increasingly at risk as the state pursues high concentration of intermittent renewables.**

- **renewable hydrogen can and ought to be integral to California's environmental justice leadership by ensuring that disadvantaged communities have priority when it comes to renewable hydrogen investments to reduce emissions, augment utility services, and add local jobs.**

Multiple Applications and Market Opportunities

Detailed below are five potential major use areas for renewable hydrogen in California. Market opportunities for each one must be expanded to reach the volume of production required to achieve low cost renewable hydrogen, and industry growth and stability. Just as the solar photovoltaics industry needed supportive policies and incentives to open the market beyond niche applications like space satellites, or even residential rooftops, to achieve the deep cost declines enjoyed today, renewable hydrogen requires policy support to develop markets across a broad range of applications, in order to achieve low costs and long-term availability.

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Application 1: Zero Emissions Transportation

Hydrogen is a cornerstone of California's strategy to achieve zero emissions transportation, which is key to cleaning the air and reducing greenhouse gases in the most carbon intensive sector in the state. Hydrogen emits zero tailpipe air pollution or greenhouse gas, including in difficult use cases like medium and heavy duty trucks, and the more the electricity grid transitions to renewable sources, the more hydrogen produced with electrolysis will also help eliminate greenhouse gas and criteria pollution over the entire lifecycle of transportation fueling.

California has been instrumental in spearheading the hydrogen transportation industry, thanks to state policies, such as the Governor's Executive Order B-16-2012 and ZEV Action Plan, the Clean Vehicle Rebate Project, AB 8, and the Energy Commission's Alternative and Renewable Fuel and Technology Program. As a result, California is on its way to achieving its initial goal of 100 hydrogen fueling stations, and there are thousands of hydrogen fuel cell electric vehicles (FCEVs) on the state's roads. Automakers have also invested in hydrogen transportation technology, with several announcing FCEVs models in their lineup, including Honda, Toyota, Hyundai, GM, BMW, Daimler, Audi, and Ford.[1] Additionally, there have been several recent announcements on medium and heavy-duty vehicles from US Hybrid, Toyota, Kenworth, Loop Energy, Nikola Motors, FedEx, and UPS.[2]

However, this is just a beginning. Recent reports find that with the growing popularity of FCEVs, the roll out of hydrogen fuel stations is already not keeping up with the pace of demand.[3] And to reach the state goals of 1.5 million ZEVs on California roads by 2025 and 80% reduction in greenhouse gas emissions from the transportation sector by 2050,[4] progress needs to accelerate considerably.

Opportunities for Accelerating Market Expansion:

- ✓ Expanding the 100 station target to set a new milestone of 500 hydrogen fueling stations.
- ✓ Stabilizing the funding for the CVRP to continue to incentivize purchases of ZEVs, including FCEVs.
- ✓ Encouraging multi-sector cooperation between OEMs, utilities, and fueling station companies, similar to the EVSE model.

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[1] http://www.businessinsider.com/12-hydrogen-car-projects-2017-5/ - the-epa-recently-gave-the-car-an-estimated-range-of-366-miles-the-longest-range-of-any-zero-emissions-vehicle-honda-says-the-clarity-has-a-refuel-time-of-just-three-to-five-minutes-2

[2] https://www.trucks.com/2017/05/08/hydrogen-fuel-cell-trucks-holy-grail/; https://www.forbes.com/sites/heatherclancy/2014/01/30/run-your-engine-on-water-sprint-fedex-test-hydrogen-fuel-cells/#736b4ef874ec

[3] http://www.northbaybusinessjournal.com/northbay/sonomacounty/7051792-181/sonoma-marin-hydrogen-fuel-cell-vehicle?artslide=0

[4] https://www.gov.ca.gov/news.php?id=17472

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- ✓ Leveraging the LCFS program to expand production and distribution of power-to-hydrogen for transportation.

Application 2: Energy Storage

As the state advances toward ever higher renewable electricity targets, curtailment is increasing.[5] As the state progresses to 50% and higher penetrations of mostly variable renewable generation, like solar and wind power, state regulators and grid operators are projecting an increased need for energy storage, including large scale, long duration (up to seasonal) storage. The geographic limitations of pumped hydro and compressed air storage will require additional large scale storage solutions. Renewable hydrogen can play a unique role in providing lower-cost geographically flexible seasonal storage up to the terawatt-hour scale.

Opportunities for Accelerating Market Expansion:

- ✓ High renewable electricity targets create a prime opportunity to encourage the hydrogen storage market. As CHBC explained in previous comments, renewable hydrogen turns the "duck curve" problem - caused by over-generation of high amounts of renewable electricity when there is not enough demand - into an opportunity. Mechanisms are needed that allow low or no cost surplus renewable electricity to be repurposed, instead of curtailed, to inexpensively produce renewable hydrogen and enable more renewable electricity to be integrated economically into the grid, or directly consumed as an alternate form of renewable energy.
- ✓ EPIC funds could be used to expand upon demonstration projects in the state.
- ✓ Creating a next phase of mandated storage procurement that includes hydrogen as an eligible source is an additional step that ought to be taken.
- ✓ The ancillary service market ought to be opened up to allow power-to-hydrogen facilities to participate as a storage source that supplies grid services, such as frequency response, regulation, voltage control, energy shifting, arbitrage, etc..

Application 3: Electric Distribution System Support

As the distribution grid increasingly accommodates new intermittent generation resources and loads, like distributed solar and wind and electric vehicles, electric distribution system managers need to manage increasing amounts of distribution-level generation and new types of load during certain times of day. Rather than look to only system upgrades as a potential solution to modernize the distribution system, other forms of load management strategies can be employed like distributed or smaller-scale electrolyzers. The benefits of electrolyzer technology is that it is scalable and geographically flexible. Hydrogen helps provide a flexible, scalable solution to both these challenges by being able to absorb surplus generation from short to continuous periods, using the electricity to make hydrogen via electrolysis for multiple

[5] http://www.utilitydive.com/news/prognosis-negative-how-california-is-dealing-with-below-zero-power-market/442130/

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possible applications – and conversely, supplying the grid with power as needed via fuel cells or existing power plants.

Opportunities for Accelerating Market Expansion:

- ✓ SB350, among other provisions, has opened a potential market opportunity by requiring increased distributed generation, which increases the need for absorbing surplus electricity, and mandating vehicle electrification, which increases the need for readily available, zero-carbon supply. The law's integrated resource planning provision is also an opportunity to include renewable hydrogen solutions in long term plans for providing reliable, cost-effective, and flexible distribution grid services.
- ✓ Special pricing on wholesale electricity and gas markets, as suggested in Application 2 above could be leveraged.
- ✓ EPIC funding could go toward researching and developing projects focused on the deployment of power-to-hydrogen solutions to manage intermittent generation and loads in the distribution system.

Application 4: Industrial Sector

Renewable hydrogen can replace conventional hydrogen production and help decarbonize refineries, which emit 31% of greenhouse gases from California's industrial sector.[6] For large emitters that use hydrogen, like refineries and fertilizer producers, options are limited for meeting greenhouse gas reduction requirements. Renewable hydrogen provides an important, greenhouse gas free, drop-in alternative.

Opportunities for Accelerating Market Expansion:

- ✓ California's ambitious mandate to reduce greenhouse gas and the state's cap and trade, and LCFS programs could be accessed to encourage large emitters that use hydrogen to replace conventional hydrogen with renewable hydrogen.
- ✓ Incentives to purchase renewable hydrogen offered to all industrial hydrogen buyers could be developed.

Application 5: Power Plants and Fuel Cells for Electricity Generation

Hydrogen could replace a large majority of the natural gas going into power plants, which are the biggest end users of natural gas in California. [7] Replacing fossil fuel natural gas with renewable hydrogen could help reduce greenhouse gas emissions from a major source of electricity that helps stabilize the grid, lower air pollution from power plants that presents a health hazard to communities, and avoid electric generation stranded assets funded previously by California ratepayers.

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[6] Source: CARB; *https://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2014/ghg_inventory_trends_00-14_20160617.pdf*

[7] https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_sca_a.htm

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Renewable hydrogen can also help to scale up zero-emissions fuel cells for power generation, which are already being commercially installed in California at the megawatt scale.

Opportunities for Accelerating Market Expansion:

- ✓ Natural gas power plants currently have to pay when they emit greenhouse gas emissions, as part of the state's cap and trade program. These funds could go toward renewable hydrogen development and also act as an incentive to invest in hydrogen as a cleaner form of fuel for power plants. EPIC funds could go toward researching and demonstrating the concept.
- ✓ In addition to the wholesale electricity market offering rates for power-to-hydrogen facilities, as recommended in CHBC's original comments, the wholesale gas markets could offer an above-market rate for hydrogen made using grid power that reflects its green attribute, and which could be paid for, for example, by cap and trade, LCFS or AB8 funds.
- ✓ Renewable hydrogen should be categorized as an eligible renewable fuel for the state RPS and clean energy procurement goals.

Why California is the Right Place to Be Opening a Renewable Hydrogen Market

Large and growing demand for hydrogen that must align with climate and clean air goals

California is the state with the second largest use of hydrogen in the US, which produces 10 million metric tons annually.[8] Total annual hydrogen production capacity in California is more than 1.8 million metric tons.[9] Historically, California's hydrogen production has been driven mainly by the state's oil refining industry and large agricultural sector's appetite for fertilizer. Looking ahead, as California focuses on increasing use of hydrogen fuel cells for vehicles, equipment and other clean technology applications, this demand is set to rise. This growing need for hydrogen coupled with California's goals to reduce greenhouse gas emissions and criteria air pollutants creates a compelling case for accelerating expansion of the renewable hydrogen market.

Need to integrate large amounts of renewable power generation

As part of its strategy for reducing emissions, as well as for eliminating other environmental impacts and economic uncertainties related to fossil fuel use, California is on a trajectory to transition toward renewable electricity. Currently at about 27% generation from RPS-eligible sources with a 50% RPS by 2030 goal, a range from about 6-12% large hydropower, and expanding amount of more than 5000 MW of small-scale renewable installations like rooftop solar, the state is on its way to generate the majority of its electricity demand from renewable or zero-emissions sources within the next dozen years. Added to this is growing interest among

[8] Source: Brian Pivovar, NREL

[9] Based on IHS Chemical Economics Handbook statistic that California's daily hydrogen production is 5.1 million kg (5.1 million kg to metric tons is 5100 x 365 = 1,861,500).

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state leaders in raising the renewable or zero emission generation target to 100%. Also, the California's goal to increase battery electric vehicles requires concurrent increase of renewable electricity to power those vehicles, in order to meet state greenhouse gas targets.

A challenge accompanying the state's progress toward a mostly or all renewable electricity mix is the risk of curtailment of renewable generation. Curtailment is already happening in larger volumes than anticipated, with CAISO's 2021 curtailment projections already occurring this past spring.[10] To address this growing challenge, there will be need to aggressively adopt solutions to integrate the increasingly high amounts of renewable generation that will be penetrating the grid, in order to ensure reliable, economical services. Renewable hydrogen facilities, as previously explained, provide a solution by using otherwise curtailed renewable generation to power electrolysis to produce hydrogen, with the unique capability of absorbing surplus generation continually and storing the energy at the terawatt-hour scale. The hydrogen can be used for any of the other applications described above.

Opportunity to model environmental justice leadership

As California supports hydrogen market development, it also has the chance to apply its commitment to environmental justice and become a role model for other regions on how to adopt a socio-economically inclusive approach. The state ought to seek chances along the way to benefit disadvantaged communities most impacted by transportation, power plant, or industrial emissions, or that are underserved by utility services and ensure they have priority when it comes to renewable hydrogen investments to reduce emissions, augment utility services, and add local jobs.

For example, targeted efforts to replace diesel trucks in heavily traveled freight corridors, within impacted disadvantaged communities should be a priority for state policy leaders. These underserved communities can and should be strong candidates to benefit from new state renewable gas policies and programs that can promote:

1) Investment in ZEV heavy-duty transportation to replace diesel trucks and buses
2) New renewable hydrogen production from underutilized, curtailed regional solar and wind farms
3) Full utilization of regional wind and solar farms as feedstock for the new ZEV hydrogen fleet's fueling stations
4) Increased hydrogen fueling station infrastructure in these regions
5) Investments in new, expanded gas service infrastructure to provide renewable gas service to those not currently served

Through public policies and private investments, specifically commitments from wind, solar and other renewable electricity generators, hydrogen production companies, hydrogen fueling

[10] https://www.rtoinsider.com/caiso-duck-curve-curtailments-42004/

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station providers, and electric and gas service providers, cross-sector energy infrastructure and services can be developed. This new infrastructure and service has the potential to bring California much closer to meeting its climate goals, dramatically improve air quality in regions heavily impacted by high levels of goods movement, create in-state jobs, and leverage the investments made to date in renewable energy facilities to utilize their full capacity, all the while making our undeserved communities a priority for improved air quality, new essential gas services, and green jobs.

Conclusion

California has a remarkable history of advancing policies and incentives that broaden markets for clean energy technologies, so they can reach economies of scale and achieve full industry maturity. In addition to solar PV, LEDs are another example of a clean technology that California policy helped expand beyond niche industry uses to eventually go from most expensive to cheapest available light bulb option across sectors.[11] Renewable hydrogen holds similar promise to become a ubiquitous, multi-market, clean energy solution that helps California realize its important climate, air quality, renewable energy and environmental justice goals. To reach its full potential, however, the industry will need immediate policy and regulatory support to open markets across multiple applications.

Thank you for your consideration.

Sincerely,

Emanuel Wagner
Assistant Director
California Hydrogen Business Council

[11] Source: Goldman Sachs - http://www.goldmansachs.com/our-thinking/pages/new-energy-landscape-folder/report-the-low-carbon-economy/report-2016.pdf