BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

COMMENTS OF CALIFORNIA HYDROGEN BUSINESS COUNCIL ON THE ADMINISTRATIVE LAW JUDGE'S RULING SEEKING COMMENT ON PROPOSED SCENARIOS FOR THE 2019-2020 REFERENCE SYSTEM PORTFOLIO

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The California Hydrogen Business Council (CHBC) welcomes the opportunity to submit the following comments pursuant to the Administrative Law Judge's (ALJ) Ruling Seeking Comments on Proposed Scenarios for the 2019-2020 Reference System Portfolio, dated February 11, 2019 (ALJ Ruling). The CHBC is comprised of over 100 companies and agencies involved in the business of hydrogen. Our mission is to advance the commercialization of hydrogen in the energy sector, including transportation, goods movement, and stationary power systems to reduce emissions and dependence on oil.[1]

[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 of the CHBC include Advanced Emission Control Solutions, Air Liquide Advanced Technologies U.S., Airthium, Alameda-Contra Costa Transit District (AC Transit), American Honda Motor Company, Anaerobe Systems, Arriba Energy, Ballard Power Systems, Bay Area Air Quality Management District, Beijing SinoHytec, Black & Veatch, BMW of North America, California Performance Engineering, Cambridge LCF Group, Center for Transportation and the Environment (CTE), CNG Cylinders International, Community Environmental Services, CP Industries, DasH2energy, Eco Energy International, ElDorado National – California, Energy Independence Now (EIN), EPC - Engineering, Procurement & Construction, Ergostech Renewal Energy Solution, EWII Fuel Cells, First Element Fuel, FuelCell Energy, GenCell, General Motors, Geoffrey Budd G&SB Consulting Ltd, Giner ELX, Gladstein, Neandross & Associates, Greenlight Innovation, GTA, H2B2, H2Safe, H2SG Energy Pte, H2Tech Systems, Hitachi Zosen Inova ETOGAS GmbH, HODPros, Hydrogenics, Hydrogenious Technologies, Hydrogen Law, HydrogenXT, HyET - Hydrogen Efficiency Technologies, Hyundai Motor Company, ITM Power, Ivys, Johnson Matthey Fuel Cells, Kontak, KORE Infrastructure, Life Cycle Associates, Linde North America, Longitude 122 West, Loop Energy, Luxfer/GTM Technologies, McPhy Energy, Millennium Reign Energy, Montreux Energy, National Renewable Energy Laboratory (NREL), Natural Gas Fueling Solutions – NGFS, Natural Hydrogen Energy, Nel Hydrogen, New Flyer of America, Next Hydrogen, Noyes Law Corporation, Nuvera Fuel Cells, Pacific Gas and Electric Company - PG&E, PDC Machines, Planet Hydrogen, Plug Power, Port of Long Beach, PowerHouse Energy, Powertech Labs, Primidea Building Solutions, Proton OnSite, RG Associates, Rio Hondo College, Rix Industries, Sacramento Municipal Utility District (SMUD), SAFCell, Schatz Energy Research Center (SERC), Sheldon Research and Consulting, Solar Wind Storage, South Coast Air Quality Management District, Southern California Gas Company, Sumitomo Corporation of Americas, Sunline Transit Agency, T2M Global, Tatsuno North America, The Leighty Foundation, TLM Petro Labor Force, Toyota Motor Sales, True Zero, United Hydrogen Group, US Hybrid, Verde, Vinjamuri Innovations, Volute, WireTough Cylinders, Zero Carbon Energy Solutions.

I. COMMENTS TO QUESTIONS IN THE ALJ RULING AND ATTACHMENT A

1. Do you agree with the proposed 2045 framing study scenarios? What modifications should be made to better characterize the role of the electricity sector in meeting California's GHG reduction goals in 2030 and beyond, given the zero-carbon goals outlined in SB 100 and imperfect information regarding future GHG reductions in other sectors of the economy? Provide detailed data sources which may be used in order to construct your recommended scenarios.

CHBC supports the Commission's efforts to undertake the proposed framing study as part of the IRP 2019/2020 cycle and appreciates the Commission including the "2045 high hydrogen scenario" in the Reference System Plan (RSP). We agree that it is important to further examine the role of the electricity sector in view of SB100 and also to better understand the impacts of decarbonization across sectors, as called for by policies such as Executive Order B-55-18.

CHBC believes that a technical correction is needed in the "Brief Description" of the proposed "2045 High Hydrogen Scenario" in the chart on p. 4 of Attachment A, in order to accurately describe hydrogen as an energy carrier. The description should be changed as follows (new language in bold):

> *Emphasizes hydrogen as an energy carrier produced from a centralized, grid- connected ~~personal electric vehicle (PEV)~~* ***Polymer Electrolyte Membrane (PEM) electrolysis****. It is used in vehicles and as a natural gas replacement in the pipeline.*

The CHBC notes that this set of use cases is a limited subset of those for which grid connected electrolyzers can be used. In particular, the scenario should include the use of hydrogen as a storage resource wherein electrolytic hydrogen is used to produce electricity (which can be termed Power-to-Gas-to-Power). Electrolyzers can also provide voltage support, frequency support and ramping. This capability has the potential to reduce the cost of providing those services from other resources and should be included in a properly modeled high-hydrogen case.

CHBC is concerned that the existing scenarios listed in attachment A of the ruling incorrectly and unnecessarily make a high electrification and a high hydrogen scenario mutually exclusive. A high electrification scenario would greatly benefit from, if not necessitate, the long duration energy storage attributes of electrolytic hydrogen solutions. The high electrification scenario could also include hydrogen for electricity generation either via gas turbine or fuel cell, as well as include, if not require, hydrogen fuel cell electric transportation for applications that are suboptimal for battery electric technology, such as passenger vehicles for multi-family dwellings where plugging in is difficult, and heavy duty vehicles, ships, and other transportation technology needed for goods movement. These are just some of the cases that show that an integrated, non-exclusive approach to electrification and hydrogen will be useful to consider.

Modifications needed to the RESOLVE model

The RESOLVE model is not capable of correctly modeling a high-hydrogen scenario unless important modifications are made. RESOLVE treats electrolyzers as a load with a fixed capacity factor of 25%. Instead, electrolyzers should be modeled as a dispatchable resource that operates to maximize value by producing fuel and providing grid services (turn up, turn down, follow voltage or frequency) based on optimal dispatch (time dependent price of grid electricity and value of grid services) as are other dispatchable resources. It is also important to link hydrogen demand with electric vehicle load assumptions. For these reasons, the existing "high hydrogen" scenario in RESOLVE provides an incomplete picture. The combination of low-solar and low-wind costs with properly modeled electrolyzer dispatch will, in high likelihood, improve the economics of the electric system and the transportation sector. Senate Bill 1369 mandates that electrolytic hydrogen be treated as an eligible as a storage resource, directing the "*PUC, State Air Resources Board, and Energy Commission to consider green electrolytic hydrogen an eligible form of energy storage, and to consider other potential uses of green electrolytic hydrogen*." The CHBC believes that the functionality of RESOLVE relative to electrolytic hydrogen needs to be extended in order to satisfy this direction.

Cross-sectoral benefits of hydrogen

Hydrogen as an energy carrier has multiple potential uses, including decarbonized electricity generation, energy storage, zero emissions transportation fuel, decarbonized building energy services like heating and cooking, and industrial applications.

As California progresses toward 100% renewable and zero carbon electricity, there will be increased need to avoid curtailment, as well as to provide long duration seasonal storage to ensure reliable power supply. Hydrogen technologies provide solutions. Electricity that would otherwise be wasted by curtailment can be used to power electrolysis that splits water to produce hydrogen, which can then be put to good use in any of hydrogen's various applications or stored until needed in storage tanks, caverns, dedicated hydrogen pipelines, or in limited quantities in the existing natural gas system. Hydrogen can also be combined with CO2 and blended seamlessly with natural gas or biomethane in the existing gas system.

Hydrogen solutions are currently the only way to store electricity at the terawatt hour scale and are more modular and flexible to site than other long duration storage options like pumped storage or compressed air.

2. Based on the various technology deployments assumed in the framing study scenarios, what implementation or feasibility assessments may be needed to better understand the costs and risks associated with the technologies that contribute to GHG reductions? How should the results of those assessments be used to evaluate which economy-wide GHG mitigation policy pathways to pursue and/or account for in statewide planning?

The description of Table 1 on p. 4 of Attachment A states that table's "assumptions and results are derived from CEC's *Deep Decarbonization in a High Renewables Future* study." The CHBC strongly agrees with the CEC study's acknowledgement that hydrogen is among the solutions that "*will likely be necessary to meet the 2050 greenhouse gas goal and to mitigate the risk of the other greenhouse gas reduction solutions falling short*."[2] However, we believe certain

[2] CEC's *Deep Decarbonization in a High Renewables Future* study, p.3 https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf

limitations put forth in the study about hydrogen need to be revised in order to accurately assess the associated costs and risks.

First, the study incorrectly claims that electrolytic hydrogen is not yet commercially proven.[3] While it is true that full commercialization at the gigawatt scale is not projected to occur for another couple of years,[4] approximately 45 electrolytic hydrogen projects up to the multi-megawatt scale are already on line or in development in Europe,[5] in addition to several others around the world in Asia, Australia, and North America.

Second, electricity pricing assumptions in the current PATHWAYS model, on which the CEC's study derives its results,[6] need to be re-examined in a high renewable energy future. The PATHWAYS model calculates grid electricity prices for centralized hydrogen production based on the model's scenario generation supply mix, hourly electricity demand and supply, and with a 25% load factor for hydrogen production.[7] The cost of electrolytic hydrogen production, however, can fall significantly under likely future high electrification scenarios in which there is excess generation, high curtailed electricity risks, much higher load factor, and where lower or negative wholesale rates become available.

The RESOLVE model or the PATHWAYS model should also include the impacts of implementing SB 100's 100% renewable and zero carbon electricity targets, CAISO's curtailment assumptions, and electricity pricing impacts of these factors in the 2045 High Hydrogen Scenario. Curtailment and need for large scale, rapid ramping are already outpacing CAISO's forecasts. As the penetration of variable decarbonized electricity generation rises, the risk of excess generation is bound to go up, causing electricity prices to drop to low and negative levels. If electrolysis has access to these low prices, and as storage durations of more than about 4 hours become necessary (the duration at which electrolysis becomes more economically

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[3] Ibid., p. 67

[4] See, for example, Germany's long held policy to reach a gigawatt of installed electrolytic hydrogen based projects by 2022: http://www.powertogas.info/fileadmin/content/Downloads/Brosch%C3%BCren/dena_PowertoGas_2015_engl.pdf

[5] See http://europeanpowertogas.com/european-power-to-gas-platform-calls-for-grid-integrated-full-scale-p2g-demonstrations/

[6] CEC's *Deep Decarbonization in a High Renewables Future* study, Table 1.

[7] As described in page 22 and appendix (B-18) of the CEC's Study, https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf

favorable than batteries[8]), the cost analysis in the 2045 High Hydrogen Scenario will be significantly impacted.

CHBC urges the Commission to ensure that the most current information is used to include the cost reduction potential of hydrogen pathways and incorporate the cost and technical assessment data from the studies into the 2045 high hydrogen scenario analysis.

- UCI_APEP-CEC_Renewable_Hydrogen_Roadmap_Webinar_2017-HYD-01_2018-11-13.pptx,[9] The Advanced Power and Energy Program (APEP), UC – Irvine, 2018

    The University of California-Irvine is focusing on the development and deployment of efficient, environmentally sensitive, sustainable power generation and energy conversion technologies including hydrogen and fuel cells.[10] APEP has been awarded a CEC grant "*to develop a deployment roadmap for renewable hydrogen production in California through 2050. The effort will initially focus on extracting insights from the first set of renewable hydrogen production facilities under development in California and developing a roadmap for the build-out necessary to serve the growing demand for renewable hydrogen to serve transportation, power generation, and other applications. The roadmap will provide significant detail through 2025 and a higher-level outlook in five-year increments through 2050.*"[11] The deployment roadmap is evaluating techno-economics for hydrogen production including cost reduction potentials over the 2050 planning horizon. The final report is expected in mid 2019. APEP is also developing a modeling tool, H2GRID, to analyze the impact and benefits of deploying electrolytic hydrogen across the CAISO grid.

- National Hydrogen Roadmap: Pathways to an economically sustainable

[8] As described in CHBC's comment submission to the CEC's *2017 Integrated Energy Policy Report* titled *Economics of Power to Gas,* https://efiling.energy.ca.gov/URLRedirectPage.aspx?TN=TN219923_20170626T180524_Emanuel_Wagner_Comments_Economics_of_Power_to_Gas.pdf

[9] https://www.energy.ca.gov/altfuels/2017-HYD-01/documents/

[10] http://www.apep.uci.edu/.

[11] http://www.apep.uci.edu/NewsAndEvents/APEP_Receives_CEC_Grant_For_California_Renewable_Hydrogen_Deployment_Roadmap_090518.aspx

hydrogen industry in Australia, CSIRO, 2018 [12]

The National Hydrogen Roadmap provides a blueprint for the development of a hydrogen industry in Australia. The report provides detailed cost-economics including levelized cost of hydrogen and cost reduction potentials for hydrogen production and storage.

- World Energy Council – E Storage Report, 2016 [13]

  A report from the World Energy Council that evaluates the levelized cost of energy storage including power to hydrogen over the 2030 planning horizon with a comparative outlook across other storage resources.

- Study on Early Business Cases for H2 in Energy Storage and More Broadly Power to H2 Applications, Fuel Cell and Hydrogen Joint Undertaking, June 2017 [14]

  The report identifies early business cases for hydrogen in energy storage and to assess their potential replicability within the EU until 2025. The report provides techno-economic and performance data of hydrogen energy storage technologies.

- The Potential of Power-to-Gas, Enea Consulting, January 2016 [15]

  This study evaluates the economic potential of power-to-hydrogen and other power-to-X applications with a techno-economic modelling of six case studies targeting energy markets across multiple time horizons (2030 and 2050).

CHBC requests the Commission to list the detailed data inputs including cost reduction potential, average grid electricity price assumptions under low, medium and high curtailment cases and other technical assumptions to be used in the 2045 high

[12] https://www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap.
[13] https://www.worldenergy.org/wp-content/uploads/2017/03/WEResources_E-storage_2016.pdf .
[14] http://www.fch.europa.eu/publications/study-early-business-cases-h2-energy-storage-and-more-broadly-power-h2-applications.
[15] http://www.enea-consulting.com/wp-content/uploads/2016/01/ENEA-Consulting-The-potential-of-power-to-gas.pdf.

hydrogen scenario for stakeholder review and validation. The currently available data on the CEC's Report is limited to energy efficiency, levelized costs and load factor for hydrogen production and liquefaction.[16]

3. Do you recommend alternative scenarios or sensitivities for the 2030 timeframe that should be studied? If so, provide detailed rationale and data sources for the proposed additional scenarios.

No comment at this time.

II. COMMENTS TO QUESTIONS IN THE ALJ RULING AND ATTACHMENT B

4. Should the default assumption for core scenarios rely on the economic retention functionality in RESOLVE? Why or why not?

No comment at this time.

5. Is it reasonable to implement staff's suggested minimum local capacity requirement constraint as an interim approach for dealing with local reliability issues? Or if you prefer a different approach, explain in detail.

No comment at this time.

6. Comment on staff's suggested "energy sufficiency" approach as described in Step 2 of Attachment B.

No comment at this time.

7. Are there other reliability checks that you would recommend? Describe in detail.

No comment at this time.

[16] As described in appendix (B-18) of the CEC's Study, https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf

8. Staff would like to apply the economic retention functionality to all thermal generators; however, cogeneration facilities raise a particular challenge due to the need to consider the value of heat to industrial processes. This value may be substantial, and lead to resource retention in reality, even if the model demonstrates no need for the resource for electric system reliability. What specific data can be used and what interim study approach could be performed to approximate the application of economic retention functionality to cogeneration?

No comment at this time.

9. Should staff study any additional intermediate years in addition to the four IRP resource planning years (2020, 2022, 2026, and 2030) in order to better understand near- and medium-term reliability issues, or would the additional granularity result in false precision considering that RESOLVE is a capacity expansion model designed to study long-term economics? Explain.

No comment at this time.

10. Are there other specific data sources you recommend for any component of the thermal generation analysis described in Attachment B?

We recommend that the Commission consider the potential for displacing natural gas in combined cycle gas plants with hydrogen as a strategy for dcarbonizing electricity generation and avoiding stranded assets. Gas turbines that use 30% to 70% hydrogen blends are currently on the market, and 100% hydrogen gas turbines are expected to achieve commercialization soon.

11. Comment on staff's proposed improvements to the local air pollutant emissions analysis.

No comment at this time.

III. CONCLUSION

CHBC looks forward to continuing to work with the Commission and other stakeholders on understanding the important role of hydrogen energy solutions in California's energy future and how to best integrate those findings into the IRP process.

Respectfully submitted,

Emanuel Wagner

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Dated: March 5, 2019