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Comments by the California Hydrogen Business Council to Panel 5: Emerging Technologies and Market Opportunities

Additional submitted attachment is included below.

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Chairman Robert Weisenmiller
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Subject: Addendum to Comments on Joint Agency Workshop on Renewable Gas

July 14, 2017

Dear Chairman Weisenmiller,

The California Hydrogen Business Council (CHBC) submits this letter in addition to our previously submitted comments responding to specific questions by the Energy Commission, which were directed at Panel 5 on Emerging Technologies and Market Opportunities. We wish to shed light on the topics raised at the workshop that are not included in those previous comments, particularly regarding remarks made at the workshop in reference to the German government's support and market development – or lack thereof - of power-to-gas (P2G).

At the workshop, you shared your impression that Germany is no longer focused on P2G, especially methanation, and that instead the country is primarily interested in expanding regional grid cooperation and battery storage as solutions to integrate renewable electricity. It is true that Germany is focused on regional grid cooperation as a top priority for the near term, and that similar to the CAISO, German TSOs believe this is likely the most cost-effective solution for integrating renewable electricity generation up to 60-70% penetration into the power grid.[i] However, it is also true that Germany continues to focus significantly on P2G development, including methanation. Moreover, the country is <u>not</u> prioritizing batteries over P2G.

As stated by the German Federal Economic Development Agency, "Hydrogen and power-to-gas technologies occupy a prominent place in the long-term energy storage plans and future mobility and fuel strategy of the German government."[ii]

This is echoed in policy positions throughout the national government, such as the Germany Energy Agency's Power-to-Gas Roadmap and Strategy Platform that targets 2020-2025 for 1 GW installed and full commercialization of P2G[iii] and the German Federal Environment Agency's approach to achieving near carbon neutrality. This was summed up by the former agency leader (now State Secretary at the Ministry for Energy and Economics), Jochen Flasbarth, as follows:

"The essential component in the transition to a society that is almost completely greenhouse gas-neutral is to convert the power which will be produced entirely from renewables into hydrogen, methane and long-chain hydrocarbons."[iv]

In keeping with this view, fellow State Secretary at the Ministry, Rainer Baake, last year called for P2G as necessary for decarbonizing existing and potentially a limited number of additional gas power plants to achieve 2050 greenhouse gas targets.[v]

In reflection of federal policy, Germany has become home to several dozen P2G projects, and its energy and environment agencies continue to focus on research and development, as well as policy implementation of power-to-gas and power-to-liquid, e.g. renewable hydrogen produced by electrolysis used to make gas (hydrogen or synthetic methane) and synthetic liquid fuel. In the last year, the German Federal Environment Agency issued two in-depth analytical position papers on these topics.[vi]

You rightly pointed out that Germany is facing great challenges to reaching its ambitious greenhouse gas reduction targets. While their emissions are not going up as you suggested, they have been fairly flat since about 2010, similar to what we're seeing in California.[vii] The German Federal Environment reports that the main reason that emissions did not decline last year in Germany was aviation and heavy-duty truck emissions.[viii] Notably, these are two application challenges that hydrogen-based solutions have great potential to effectively address. The German Federal Environment Agency finds that hydrogen-based jet fuel holds significant promise to become a drop-in renewable fuel that has "profound advantages"[ix] in terms of greenhouse gas emissions, water use, and scalability compared to other known alternatives, including biofuels. The agency urges favorable policies and low electricity pricing aimed at helping power-to-liquid for aviation achieve economic competitiveness. California ought to consider a parallel approach.

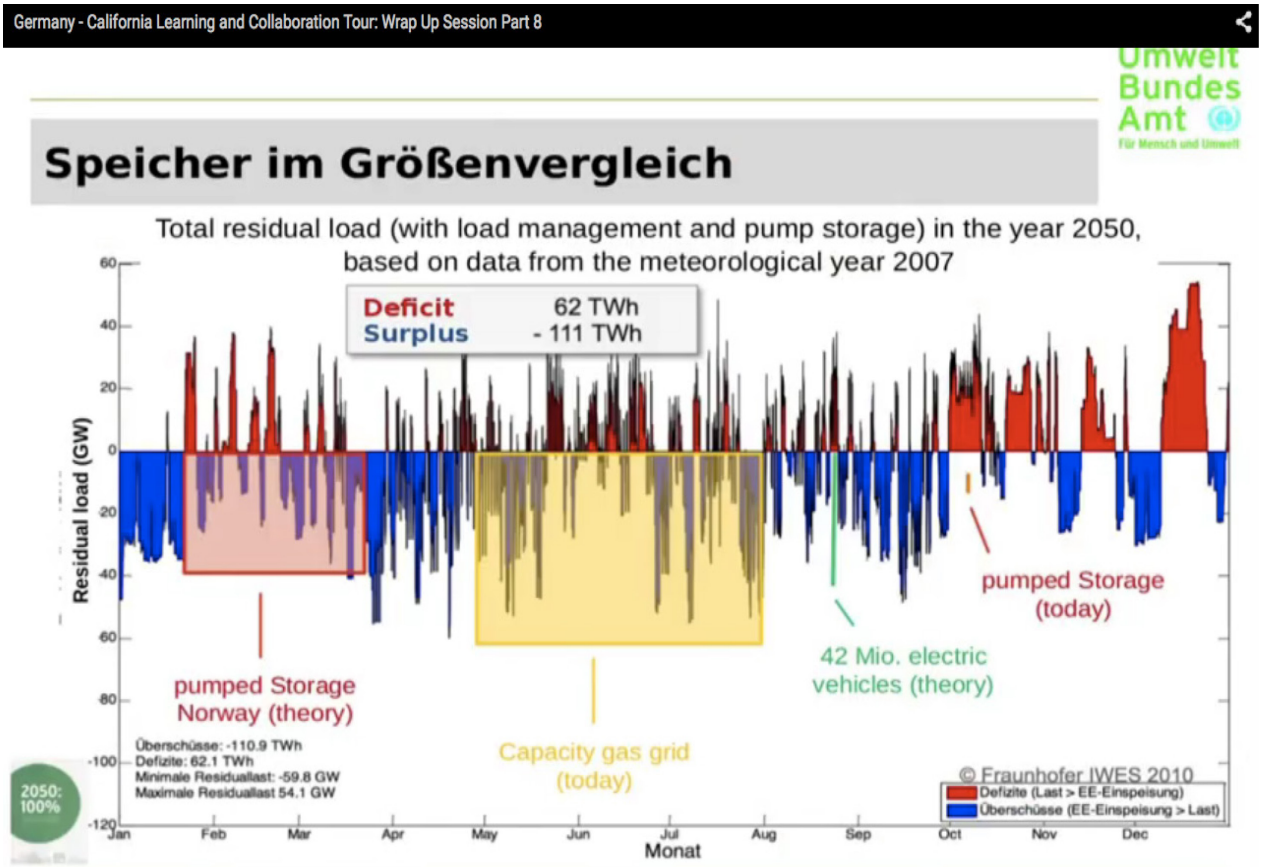
Hydrogen-based solutions also provide scalable, renewable energy options for zero emissions heavy-duty vehicles. To this end, Germany's federal government has a well-established program for R&D and market development of hydrogen fuel cell technology.[x]. Also in Germany, the first low floor passenger train powered by a hydrogen fuel cell, which produces electrical power for the traction, recently had a successful 80 km/h test run, with a 140 km/h test run completed in the Czech Republic using the same technology[xi] and similar trials being done in Canada.[xii] California likewise, of course, has a long-time policy of supporting hydrogen fuel cells for vehicles. To be clear, non-subsidized hydrogen for zero-emissions transportation will become most cost-effective if other markets for hydrogen are developed concurrently, in order to achieve economies of scale.

Additionally, ultra-low NOx methane-fueled engines are the only CARB compliant, currently commercially available option for 8.9 L heavy duty truck engines - with 11.9 L versions expected later this year -, and the only way to supply renewable fuel for these engines at mass scale is using methane produced using P2G technology. In view of P2G's positive greenhouse gas and scalability features, it is also central to Germany's approach to making road freight transportation greenhouse gas neutral.[xiii] We urge California to adopt similar policies.

With regard to battery storage development in Germany, large-scale installations are modest compared to California – 200 MW of large scale battery storage is expected by the end of 2017 – with more activity in the small-scale residential sector.[xiv] Government support has been limited, and there are currently no plans for that to significantly change. The Federal Ministry of Energy and the Economy gives this restrained view on its website: "*Currently available electrochemical storage facilities do not deliver the necessary technological and commercial conditions for both uses (transportation and storage).*"[xv]

You alluded to the difference between Germany's hydropower capacity, which is about 3% of total capacity, compared to California's, which is about 6-14% capacity. Notably, Germany's energy system is also interconnected with ten countries with a total transfer capacity of more than 20 GW of hydropower. *Despite this,* the German government is still intent on supporting additional P2G development because, as the figure below illustrates, modeling has shown that the capacity of P2G for integrating high penetrations of renewable power up to 100% in Germany exceeds that of "out of country" (namely Norway) hydropower, thereby providing an even larger storage resource.

Storage Size Comparison for Germany



Moreover, a study conducted by McKinsey & Company found that converting renewable power into hydrogen by P2G followed by salt cavern hydrogen storage and use of combined cycle power plant conversion back to electricity (called Power-to-Power, P2P) was cheaper than pumped hydro storage. The findings showed that P2P with a round trip efficiency of 40% and capital costs of $1000/kW has a lower levelized cost of electricity than pumped hydro storage, the current lowest cost energy storage solution. [xvi]

Lastly, the European Union also continues to support and build the framework for the technology. The June 2017 Report for the Fuel Cells and Hydrogen 2 Joint Undertaking, states that "*within the portfolio of storage technologies, hydrogen is widely recognized as a promising option for storing large quantities of renewable electricity over longer periods*.[xvii]" (Full report submitted on this docket.) One conclusion of the comprehensive report is that power-to-hydrogen is bankable already today, but needs to be allowed to stack up several revenue streams from a variety of market applications. With that, revenues from providing frequency services to the

power system (frequency containment and/or restoration reserves) will significantly improve bankability and cut payback times.

Thank you for your consideration. We are available to provide further guidance and literature if you so desire.

Sincerely,

Emanuel Wagner
Assistant Director
California Hydrogen Business Council

CC:

The Honorable Jim Beall, Chair of Senate Transportation Committee
The Honorable Bob Wieckowski, Chair of Senate Environmental Quality Committee

About the CHBC:
The CHBC is a California industry trade association with a mission to advance the commercialization of hydrogen in transportation and stationary sources to reduce greenhouse gas, criteria pollutant emissions and dependence on oil. 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 AC Transit, Air Liquide Advanced Technologies U.S. LLC., American Honda Motor Co., Inc., Ballard Power Systems, Bay Area Air Quality Management District, Beijing SinoHytec, BMW of North America LLC, California Air Resources Board, California Fuel Cell Partnership, California Performance Engineering Inc., CALSTART, Cambridge LCF Group, Center for Transportation and the Environment, China Hydrogen Fuel Cell Corporation, Coalition for Clean Air, Community Environmental Services, E4 Strategic Solutions, ElDorado National – California, Energy Independence Now, Engineering, Procurement and Construction, LLC, Ergostech Renewal Energy Solution, First Element Fuel Inc, FuelCell Energy, Inc., General Motors Corporation, Giner, Inc., Gladstein, Neandross & Associates, Greenlight Innovation, GTA, Inc., GTM Technologies Inc., H2B2, H2Safe, LLC, H2SG Energy Pte Ltd, H2Tech Systems, Horizon Fuel Cells Americas, Inc., Hydrogenics Corporation, Hydrogenious Technologies, HydrogenXT, Hyundai Motor Company & Kia Motors Corp, i-2-m, Idaho National Laboratory, Intelligent Energy, IRD Fuel Cells LLC, ITM Power Inc, Ivys Inc., Johnson Matthey Fuel Cells, Linde North America Inc, Loop Energy Inc, McPhy Energy, MPL Consulting, Inc., National Renewable Energy Laboratory, Nel Hydrogen, New Flyer of America Inc, Next Hydrogen Corporation, Noyes Law Corporation, Nuvera Fuel Cells LLC, Pacific Gas and Electric Company, Paramount Energy West LLC, PDC Machines, Inc., Plug Power, Inc., Port of Long Beach, PowerHouse Energy Americas, Powertech Labs, Inc., Proton OnSite, Ramco Consulting Company Inc, Rio Hondo College, RIX Industries, Sacramento Municipal Utility District, SAFCell Inc, Schatz Energy Research Center, Solar Hydrogen System, South Coast Air Quality Management District, Southern California Gas Company, Sumitomo Corporation of Americas, SunLine Transit Agency, Tatsuno North America Inc, Terrella Energy Systems Ltd, Toyota Motor North America Inc., Advanced Power and Energy Program - UC Irvine, United Hydrogen Group Inc, US Hybrid Corporation, WireTough Cylinders, LLC, Zero Carbon Energy Solutions, Ztek Corporation

ENDNOTES

[i] Source: Presentations by 50Hertz CEO Boris Schucht and TenneT COO Ben Voorhorst at 2015 Stakeholder CAISO
[ii] 2017/2018 *Fact Sheet on The Energy Storage Market in Germany*, GTAI
https://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Fact-sheets/Energy-environmental/fact-sheet-energy-storage-market-germany-en.pdf?v=9
[iii] See: http://www.powertogas.info/english/roadmap-power-to-gas/
[iv] https://www.umweltbundesamt.de/en/press/pressinformation/a-greenhouse-gas-neutral-germany-is-almost-possible

[v] https://www.cleanenergywire.org/news/phasing-out-conventional-cars-close-call-rwe
[vi] See: https://www.umweltbundesamt.de/publikationen/integration-of-power-to-gas-power-to-liquids-into; http://www.lbst.de/ressources/docs2016/161005_uba_hintergrund_ptl_barrierrefrei.pdf
[vii] Source: German Federal Environment Agency: https://www.umweltbundesamt.de/en/press/pressinformation/climate-footprint-2016-transport-sector-cool; CARB: https://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2015/ghg_inventory_trends_00-15.pdf
[viii] ibid.
[ix] ibid, p. 26
[x] http://www.now-gmbh.de/en/about-now
[xi] http://www.alstom.com/press-centre/2017/03/alstoms-hydrogen-train-coradia-ilint-first-successful-run-at-80-kmh
[xii] http://www.torontosun.com/2017/06/15/ontario-studying-using-hydrogen-fuel-cells-to-power-go-trains
[xiii] See: https://www.umweltbundesamt.de/sites/default/files/medien/377/publikationen/uba_position_powertoliquid_engl.pdf
[xiv] https://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Fact-sheets/Energy-environmental/fact-sheet-energy-storage-market-germany-en.pdf?v=9
[xv] http://www.bmwi.de/Redaktion/EN/Artikel/Energy/research-priorities-energy-storage.html
[xvi] McKinsey & Company, "Commercialisation of Energy Storage in Europe," Fuel Cell and Hydrogen Joint Undertaking, European Commission, March, 2015.
[xvii] http://www.fch.europa.eu/sites/default/files/P2H_Full_Study_FCHJU.pdf