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CHBC Comments on 2019 IEPR Near Zero Electricity Workshop

October 17, 2019

I. Introduction

The California Hydrogen Business Council (CHBC)[1] appreciates the Energy Commission hosting the recent workshop on Near Zero Carbon Electricity as part of the 2019 IEPR process and welcomes the opportunity to submit the following comments.

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.

CHBC believes this discussion is critical to successful implementation of the State's climate and clean energy policies. There are two main takeaways from the workshop on which we hope the Energy Commission will focus its attention, as it prepares the 2019 IEPR and advances other related policy efforts:

- **Experts shared that solar, wind, hydro, and batteries, while important, will not allow California to achieve its clean energy and climate goals alone; innovation and investment in additional solutions will be needed, and hydrogen ought to be considered among them.**

- **An international call to action is growing to develop policies and investment now that advance hydrogen, and California has an opportunity to lead the way.**

II. Comments

a. Experts presenting at the workshop from EFI and E3 shared that solar, wind, hydro, and batteries, while important, will not allow California to achieve its clean energy and climate goals alone; innovation and investment in additional solutions will be needed, and hydrogen and fuel cells ought to be among those considered.

[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/

1. ***EFI asserted that hydrogen is a key solution to managing variations in seasonal demand and supply of electricity in California, as California transitions to renewable power generation.***

The presenter from Energy Futures Initiatives (EFI) made the case that fuel will be needed to ensure stable electricity supply through seasonal shifts in supply and demand, as California transitions to predominantly variable renewable power. To illustrate, she showed using real data that there was a large seasonal delta of 3.1 TWh between June and January 2016 with deployment of just solar and wind (Slide 10).[2] She pointed out that hydropower as a solution to help bridge this gap is unreliable due to being drought prone, and batteries with 4-hour storage capability will also not be capable of addressing this challenge of seasonal variation. Li-ion batteries, she added also have mineral requirements that risk impacting the pricing, public health, and humanitarian values associated with mining.

To meet the challenge, she explained that EFI has concluded fuel will be required. She assessed that while hydrogen faces near term challenges to reach full commercialization as an electricity system asset, in the 2050 time frame, it is a hugely important focus of innovation and investment - and that hydrogen produced with renewable electricity can get California to its net zero carbon emissions target.

2. ***EFI concludes that long duration storage is a top strategy for reducing GHG from the electricity system – an application to which hydrogen is particularly well suited.***

The top two strategies EFI identified for reducing GHG from the electricity system are natural gas combined cycle with carbon capture, utilization and storage, and renewables with up to 10-hour storage (Slide 6).[3] Hydrogen is an ideal solution for coupling renewable generation with long duration storage. Unlike batteries, which can only absorb electricity for a few hours and can only hold the electricity for a limited time before discharging, electrolysis can store electricity for any time period, 24/7, and can utilize the energy as hydrogen, for example in designated tanks or pipelines, for as long as needed. That hydrogen can be used for a range of applications with fuel cells, such as zero emissions transportation, decarbonized gas end uses, ancillary grid services, electricity generation or heating. At durations of above approximately 5 kWh, electrolytic hydrogen storage returned to electricity becomes more cost effective than lithium ion batteries.[4] Pursuing hydrogen as a storage medium is in line with SB 1369, which directs state agencies to consider green electrolytic hydrogen as an eligible form of energy storage.[5]

3. ***Hydrogen also stands to play critical roles in strategies for decarbonizing other sectors identified in the EFI presentation, such as industry.***

Fuel switching to hydrogen is shown to be one of the top two pathways for reducing emissions from the industry sector in the EFI presentation. (Slide 6).[6] This finding was more recently validated in a study

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[2] See *Optionality, Flexibility & Innovation - Pathways for Deep Decarbonization in California* TN-229819 Submitted 9/23/2019; https://ww2.energy.ca.gov/2019_energypolicy/documents/2019-09-24_workshop/2019-09-24_presentations.php

[3] Ibid.

[4] See Slide 11/18, *Why We Need Hydrogen and Fuel Cells for our Renewable Future,* Dr. Jack Brouwer, NFCRC, October 3, 2018 https://static1.squarespace.com/static/5b02e08a506fbe726e4dbbd2/t/5bbe587d1905f4e8e181491f/1539201155696/Brouwer%5C_OFCC%5C_Symposium%5C_100318.pdf

[5] Sec 2, 400.2 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1369

[6] See *Optionality, Flexibility & Innovation - Pathways for Deep Decarbonization in California* TN-229819 Submitted 9/23/2019; https://ww2.energy.ca.gov/2019_energypolicy/documents/2019-09-24_workshop/2019-09-24_presentations.php

released by Columbia University.[7] To the extent the state seems comfortable envisioning policies that will eliminate emissions from tens of millions of vehicles and buildings within just 20-30 years, addressing hundreds of industrial facilities in California could be considered comparatively simple. A coordinated approach and dedicated plan to reduce emissions in the industrial sector could likely decarbonize it long before that goal is accomplished in other sectors.

For example, according to CARB's inventory, California's dozen or so refineries generate more emissions than all of the 14 million households in California, combined. A dedicated plan and workable policy framework to repurpose curtailed renewable generation and other low-cost renewable resources to produce renewable hydrogen and deploy it, possibly combined with carbon capture, at these handful of facilities could quickly reduce emissions from this sector in its entirety, likely by 2030.

4. *E3 also points to the potential need for hydrogen to decarbonize the electricity sector and beyond.*

While E3 is more optimistic than EFI about the potential for wind, solar, flexible loads and batteries to deeply decarbonize the electricity sector, they nonetheless acknowledge in their presentation that these technologies alone cannot get California to 100% renewable and zero carbon electricity. (Slide 10).[8] They conclude that solutions, such as hydrogen for instance, will also be needed. Hydrogen is already capable of providing this service. For example:

- In Japan, Obayashi Corporation and Kawasaki Heavy Industries, Ltd., (as part of the New Energy and Industrial Technology Development Organization project) delivered the world's first gas turbine fueled by 100% hydrogen for energy and heat generation.[9]
- Mitsubishi Hitachi Power Systems has successfully developed a large-scale hydrogen gas turbine that uses up to 30% hydrogen and is in the process of developing a 100% hydrogen turbine.[10] A project underway in the Netherlands seeks to convert a natural gas power plant to 100% hydrogen using this technology.
- Mitsubishi Hitachi Power Systems has also partnered with Magnum Development to build a 1000 MW energy storage project in Utah that will deploy electrolytic hydrogen storage and hydrogen electricity generation, along with other solutions.[11]
- 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. Similar turbines are also in operation at a South Korean refinery, with more than 20 years combusting a fuel blend with more than 70% hydrogen and has 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.[12]
- Fuel cells can also provide electricity generation, along with combined heat and power, which is free of criteria pollutants. When run on renewable hydrogen, fuel cells are also free of lifecycle greenhouse gas emissions. Stationary hydrogen fuel cells up to the megawatt scale are in operation

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[7] See *Low-Carbon Heat Solutions for Heavy Industry: Sources, Options, and Costs Today;* https://energypolicy.columbia.edu/research/report/low-carbon-heat-solutions-heavy-industry-sources-options-and-costs-today

[8] See: *The Role of Electricity in Decarbonizing CA's Energy System* TN-229820 Submitted 9/23/2019. https://ww2.energy.ca.gov/2019_energypolicy/documents/2019-09-24_workshop/2019-09-24_presentations.php

[9] 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

[10] https://www.mhps.com/special/hydrogen/article_1/index.html

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

[12] 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/

today,[13] and many companies around the country are adopting fuel cells for primary and backup power including: Adobe, Apple, AT&T, CBS, Coca-Cola, Cox Communications, Delmarva Power, eBay, Google, Honda, Microsoft, Target and Walmart, among others.[14] Critical facilities, such as fire departments, hospitals, police departments, senior centers and telecommunication services are being powered 24/7 by fuel cell systems and continued operating during grid outages.

5. ***The limits of narrowing electricity generation to solar, wind, hydro, and batteries are plainly evident when considering disaster resiliency, which requires long duration backup storage and generation, and for which the best viable, scalable zero criteria pollutants, zero GHG option is hydrogen fuel cells.***

California's distributed electricity grid is vulnerable to impacts of severe weather, wildfire, and other disasters. Underground gas lines are comparatively less vulnerable than overhead power grids. To manage the risks of the power grids, electric utilities are de-energizing for hours or days at a time during high wind periods in large and potentially expanding regions of California considered at high risk for wildfires.[15] Longer term power shutdowns of weeks or longer have been shown to occur in such regions, and may occur anywhere in the rest of the state in the event of major earthquakes.[16] To cope with power shutdown risks, people are turning to fossil fuel generators, with sales spiking as much as 1400%, damaging air quality.[17] Solar and battery storage are not enough to replace this need with clean alternatives because they cannot provide zero emissions power 24/7 under all scenarios. As essential as onsite solar panels are to California's clean energy efforts, they are prone to fail during smoky fire conditions and cannot supply power during a shutdown unless they are not grid-tied, and in worst case are prone to melting in fires. While battery storage is an excellent solution for short-duration storage and generation, they are not capable long-duration storage and generation across all weather and circumstances. Additional solutions are necessary, and hydrogen fuel cells are an ideal complement.

Hydrogen is capable of long-duration storage and generation with fuel cells, even under extreme conditions. They withstood the Sonoma fires in 2018 and the 6.0 magnitude Napa earthquake in 2014, and they provided continuous generation to nine microgrids during four storms that buffeted the East Coast from March 2-22 in 2018 that caused millions to lose power.

While stationary fuel cells have conventionally run on natural gas, they can run on hydrogen, and when this hydrogen is produced using renewable electricity. The result is electricity generation that emits zero criteria and greenhouse gas emissions over its lifecycle. We strongly encourage California to support adoption of fuel cells in microgrids, onsite backup generation to promote resiliency without sacrificing air quality, and support hydrogen as a fuel supply to optimize the lifecycle environmental benefits of fuel cell technology.

6. ***E3 also points out that hydrogen may be needed for applications that are difficult to electrify.***

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[13] See, e.g. https://www.hydrogenics.com/2015/11/03/kolon-hydrogenics-starts-commercial-operation-of-megawatt-fuel-cell-system-in-south-korea/
[14] http://www.fchea.org/stationary
[15] One in four Californians now live in a areas considered at high risk of wildfires, according to the California Department of Forest and Fire Protection, as reported in the *Los Angeles Times.* https://www.latimes.com/local/lanow/la-me-california-braces-for-new-wildfires-20190614-story.html
[16] For example, in the Woolsey fire, we have learned from residents of impacted neighborhoods that they were without power for days during and after the fire, with some are still unable to interconnect back to the power grid.
[17] https://www.sfchronicle.com/business/article/Demand-for-generators-lights-up-as-PG-E-power-14054242.php

E3 identifies several use cases, such as aviation and trucking, that cannot be simply electrified, and therefore alternative approaches are needed, such as hydrogen (Slide 11).[18]

Notably, electrolytic hydrogen-based fuel may be the most technically and environmentally feasible pathway to produce renewable, zero GHG jet fuel at mass scale, due to limitations on feedstock from bio-waste and land and water requirements of biofuels made from dedicated crops.[19] The ICAO is examining electrolytic hydrogen as a basis for producing zero-GHG jet fuel and how to bring down costs to make it economically competitive.[20] Power-to-hydrogen from renewable sources can also be used to reduce greenhouse gas emissions from aviation by improving the greenhouse gas balance of biofuel processes that require hydrogen, such as hydrotreating, increasing the yields of bioenergy processes that emit excess carbon, and substituting hydrogen produced in crude oil refineries.[21]

With regard to trucking and other heavy-duty transportation, CHBC believes that this sector can be fully electrified on the timeline set forth by the Governor to eliminate diesel pollution by 2030,[22] if fuel cell electric options are deployed, along with battery electric options where appropriate. Hydrogen fuel cell technology for heavy duty vehicles carries benefits of long range, rapid fueling, low powertrain weight, and a zero emissions option where there is lack of access to charging infrastructure. Fuel cells for vehicles, unlike batteries, perform well in adverse weather conditions without range losses and in long distance freight where schedules do not allow for long wait times to recharge. Lighter payloads for onboard hydrogen compared to the heavier weight of batteries make fuel cells more economical than other ZEV options. It is a one-for-one, emissions-free replacement for non-ZEV technology while delivering similar performance and total cost of ownership competitiveness with diesel power, as production volume increases. Several manufacturers are developing first and second-generation fuel cell medium and heavy-duty trucks. For example:

- Nikola is developing a class 8 hydrogen fuel cell truck, with more than 14,000 on order and full production expected in 2022.[23]
- Toyota began operations in 2017 on two proof-of-concept Class 8 hydrogen fuel cell trucks, which have logged more than 14,000 miles at and around the Ports of Los Angeles and Long Beach, and recently launched development of ten new zero-emissions fuel-cell-electric trucks developed in collaboration with Kenworth to move cargo in the Los Angeles Region, Inland Empire, Port Hueneme and Merced.[24]
- US Hybrid has been making fuel cell engines for transit buses, step vans, and military vehicles for several years, and the company recently unveiled its first class 8 fuel cell port drayage truck.[25]
- UPS is deploying a Class 6 fuel cell vehicle for its "Rolling Laboratory" fleet of alternative fuel and advanced technology vehicles.[26]

We strongly encourage California to advance hydrogen for these applications, including hydrogen made with zero and near-zero carbon resources.

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[18] See: *The Role of Electricity in Decarbonizing CA's Energy System* TN-229820 Submitted 9/23/2019. https://ww2.energy.ca.gov/2019_energypolicy/documents/2019-09-24_workshop/2019-09-24_presentations.php

[19] See p. 8 *Power-to-Liquids, Potentials and Perspectives for the Future Supply of Renewable Aviation Fuel*, German Federal Environment Agency (UBA); September 2016 http://www.lbst.de/news/2016_docs/161005_uba_hintergrund_ptl_barrierrefrei.pdf

[20] https://www.icao.int/environmental-protection/GFAAF/Pages/Project.aspx?ProjectID=46

[21] See p. 9, *Power-to-Liquids, Potentials and Perspectives for the Future Supply of Renewable Aviation Fuel*, German Federal Environment Agency (UBA); September 2016 http://www.lbst.de/news/2016_docs/161005_uba_hintergrund_ptl_barrierrefrei.pdf

[22] https://medium.com/@GavinNewsom/a-sustainable-world-can-start-in-california-df8c0d1332d4

[23] https://nikolamotor.com/press_releases/nikola-awarded-1-7-million-u-s-department-of-energy-award-63

[24] https://pressroom.toyota.com/the-future-of-zero-emission-trucking-takes-another-leap-forward/

[25] https://www.gladstein.org/hydrogen-fuel-cell-trucks/

[26] Ibid.

7. ***Producing renewable hydrogen is a key strategy to "cultivate use of cheap electricity," as Debbi Lew shared is a lesson learned worldwide in her presentation on Maintaining Reliability in a Near-Zero Carbon Grid" (Slide 4)***

As Bloomberg New Energy Finance recently reported, "the cost of producing hydrogen gas with renewables is likely to plummet in the coming decades, making one of the most radical technologies for reducing greenhouse gases economical."[27] Similarly, former US Secretary of Energy Stephen Chu said as the cost of renewable power falls to 1.5 cents, one of the best uses for that cheap electricity is making hydrogen, adding that electricity needs to fall only below 4 cents for hydrogen to become competitive with natural gas.[28] While conventional wisdom holds that overgeneration of renewable power is a challenge associated with meeting the State's clean energy goals, using it to generate hydrogen and more completely decarbonize the power sector or other sectors instead provides tremendous, untapped opportunity.

To help electrolytic (and other forms of low and zero carbon) hydrogen become cost-competitive in California, the state will need to support achieving scale to bring down costs through long term policy frameworks and specific policy actions, such as those outlined below.

8. ***Policy action needs to be taken to ensure adequate and cost-effective zero carbon and renewable hydrogen supply is available, as it becomes increasingly essential.***

EFI identifies electrolytic hydrogen as one of eleven breakthrough technologies that stand to be "major potential contributors to California's deep decarbonization over the long-term" and concludes that "work must pick up the pace today and be sustained to support their development."[29]

UC Irvine has developed the following eleven recommendations as part of an Energy Commission funded research project on advancing renewable hydrogen production, which CHBC urges the Energy Commission to adopt:[30]

- Extend hydrogen infrastructure support to the entire supply chain
- Take steps to support a smooth expansion of production capacity that keeps pace with demand (e.g. well publicized demand forecasts; Tracking of project announcements and forecasting of long/short supply; Aggregate volume of incentives aligned with market expansion need)
- Focus on forms of support that attract private capital and support development of robust markers (e.g. debt/loan guarantees, LCFS price support, incentives)
- Reduce barriers to development in California (e.g. Program Environmental Reports, integrated permitting support)
- Design programs and incentives holistically across fuel types – pathway-specific incentives risk skewing optimal allocation of biomass feedstocks among RNG, RH2 and liquid fuels – e.g. federal RINs and proposed LCFS support mechanism

[27] https://www.bloomberg.com/news/articles/2019-08-21/cost-of-hydrogen-from-renewables-to-plummet-next-decade-bnef
[28] https://www.forbes.com/sites/jeffmcmahon/2019/04/02/get-ready-for-1-5%C2%A2-renewable-electricity-steven-chu-says-which-could-unleash-hydrogen-economy/#1ddd4e081c01
[29] p. xi, *Optionality, Flexibility & Innovation - Pathways for Deep Decarbonization in California, Summary for Policymakers,* Energy Futures Initiative, April 2019
https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/5d4c4c012023770001582b2f/1565281308104/EFI+CA+Decarbonization+SFPM
[30] See "Project Results Webinar Slides", Jeffrey Reed/UC Irvine, August 28, 2019 https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-HYD-01

- Establish electric rate structures specific to transmission-connected renewable fuels facilities (e.g. electrolyzers and liquefaction facilities) such as wholesale power market access + transmission charge
- Facilitate access to the natural gas system for renewable hydrogen transport and storage – establish blending limits and interconnection requirements
- Take steps to ensure that a mixed gas / liquid supply chain does not create barriers to market access (e.g. provide incentives for development of open access points of entry to the supply chain such as gaseous or liquid terminal facilities
- Ensure that renewable hydrogen development advances Social Justice
- Act to ensure that program eligibility, environmental accounting and lack of definitions are not barriers to renewable hydrogen development
- Increase RD&D to support market development

We also urge the Energy Commission to support the following additional policy actions:

- Support large-scale demonstration projects across sectors that include cross sector coupling
- Set procurement targets
- Encourage hydrogen blending and stationary hydrogen fuel cells for decarbonized building end uses in joint agency decision making on building decarbonization programs
- Continuing support for hydrogen transportation end uses
- Ensure zero carbon hydrogen is eligible in SB 100 implementation

b. An international call to action is growing to develop policies and investment that advance hydrogen, and California has an opportunity to help lead the way.

The call for policy action to unleash the critical benefits of hydrogen are being echoed in every corner of the world. For example:

- The **International Energy Administration** declares that this is the critical year when "governments and companies need to be taking ambitious and real-world action" to develop hydrogen's potential as a clean energy solution.[31]
- The **European Commission** recently found that the only way to achieve economy-wide 90+% greenhouse gas emissions below 1990 levels by 2050 was to aggressively pursue a diversified approach that includes hydrogen, along with electrification. [32]
- In **France**, the Minister for the Ecological and Inclusive Transition has announced a "hydrogen strategy" to utilize hydrogen across all sectors with a goal of 10% hydrogen penetration in their industrial gas use by 2023 and 20% to 40% by 2028.[33]
- In **Germany**, electrolytic hydrogen-based gas (and liquid) are cornerstones of the their deep decarbonization strategy, with national recognition that getting to 90+% greenhouse gas emissions

[31] https://webstore.iea.org/download/summary/2803?fileName=English-Future-Hydrogen-ES.pdf

[32] *A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy,* European Commission, November 28, 2018 Specifically, the first five scenarios focus on impacts of specific technology pathways, varying in the intensity of application of electrification, hydrogen, electrolytic fuels, end user energy efficiency, as well as the role of a circular economy, as actions to reduce emissions. The study found that while all of these can likely achieve 80% greenhouse gas reductions below 1990 levels, none can achieve deeper decarbonization. To reduce emissions at least 90% below 1990 levels, all five pathways must be aggressively pursued in combination (the sixth pathway). To achieve net carbon neutrality followed by net carbon negativity, however, the seventh and eighth pathways studied add to the combination scenario either negative emissions technology in the form of bioenergy combined with carbon capture and storage, or reliance on a circular economy, change in consumer choices that are less carbon intensive, and strengthening the land use sink to reduce the need for negative emissions technologies. https://ec.europa.eu/knowledge4policy/publication/depth-analysis-support-com2018-773-clean-planet-all-european-strategic-long-term-vision_en

[33] https://fuelcellsworks.com/news/french-minister-unveiled-his-100m-hydrogen-plan/

or near carbon neutrality will not be possible without this.[34] The German Energy Agency aims to ensure electrolytic hydrogen is fully commercialized by 2022.[35]

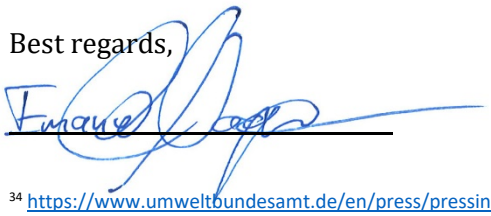
- **Japan** is aiming to be the world leader in decarbonizing by becoming a hydrogen-based society and is adopting a multi-pronged strategy for realizing this vision.[36] Showcasing this ambition, the 2020 Olympics in Japan aims to run entirely on hydrogen.
- In **China**, the "father" of their electric vehicle industry and vice chair of China's national advisory body for policymaking, is calling for "establishing a hydrogen society" and is seeking to have China become a global leader in developing hydrogen technology.[37]
- The **South Korean** government also reportedly has a US$2.33 billion public-private investment plan to accelerate hydrogen fuel cell infrastructure, manufacturing capabilities and technology development for transportation and stationary applications.[38] The 50 MW Daesan Green Energy Fuel Cell Power Plant in South Korea is under construction and will be the world's largest fuel cell installation operating on hydrogen rather than natural gas.[39]
- **Australia's** Chief Scientist states that the country's "vision is a future in which hydrogen provides economic benefits to Australia through export revenue and new industries and jobs, supports the transition to low emissions energy across electricity, heating, transport and industry, improves energy system resilience and increases consumer choice."[40] Hydrogen is being pursued as a strategy in individual states like South Australia, which is supporting renewable hydrogen development as a key economic and decarbonization strategy,[41] and in New South Wales, which is developing an electrolytic hydrogen storage project that will use existing gas pipelines to store and transport renewable electricity in the form of hydrogen.[42]
- **New Zealand** also has recently released a vision develop hydrogen as a core strategy for transitioning to a low emissions economy.[43]

California, with its abundant renewable power resources, culture of innovation, economic strength, and position as a global climate and clean energy pioneer, should lead this international effort with economic, environmental and public health benefits at home. California can make itself an economic hub for hydrogen-related jobs – just like it has for efficiency, solar power, electric transportation, and other clean technologies.

III. Conclusion

The CHBC thanks the Energy Commission for its consideration of these comments and looks forward to working with you on California's efforts to eliminate greenhouse gas emissions from electricity generation and to leveraging hydrogen as a key solution. We would be happy to discuss them further with you or answer any questions you have.

Best regards,



[34] https://www.umweltbundesamt.de/en/press/pressinformation/a-greenhouse-gas-neutral-germany-is-almost-possible
[35] https://www.dena.de/en/topics-projects/projects/energy-systems/power-to-gas-strategy-platform/
[36] https://www.meti.go.jp/english/press/2017/pdf/1226_003a.pdf
[37] https://www.supplychainbrain.com/articles/29843-chinas-father-of-electric-cars-says-hydrogen-is-the-future
[38] p. 56, *Hydrogen for Australia's Future,* Hydrogen Strategy Group (Chaired by Australia Chief Scientist, Dr. Alan Finkel); August 2018 https://www.chiefscientist.gov.au/wp-content/uploads/HydrogenCOAGWhitePaper_WEB.pdf
[39] http://www.businesskorea.co.kr/news/articleView.html?idxno=19106
[40] p. i, ibid.
[41] http://www.renewablessa.sa.gov.au/content/uploads/2019/09/south-australias-hydrogen-action-plan-online.pdf
[42] https://arena.gov.au/news/hydrogen-to-be-trialled-in-nsw-gas-networks/
[43] https://www.mbie.govt.nz/dmsdocument/6798-a-vision-for-hydrogen-in-new-zealand-green-paper

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