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CHBC Comments on CEC Staff Workshop on the Natural Gas Distribution Infrastructure and Decarbonization Targets

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I. Introduction

The California Hydrogen Business Council (CHBC)[1] appreciates the opportunity to provide comments on the June 6, 2019 Energy Commission staff workshop on the Natural Gas Distribution Infrastructure and Decarbonization Targets. Our comments focus on the presentation by Energy and Environmental Economics (E3) titled "Draft Results: Future of Gas Distribution in California." Below is an overview of our key comments and concerns regarding the assumptions and principle conclusions of the study, particularly those regarding the viability of renewable gas in comparison to electricity, followed by a Comments section that delves into more specific detail. Given the limited data available on the slide presentation, we also referred to 2018 analyses by E3 as a presumed source, and found they suggest that renewable gas could offer earlier and more reliable greenhouse gas emissions reductions than electrification, which we explain in an attached Appendix.

<u>Comments Overview</u>

1. **The E3 analysis compares costs of pathways that can achieve similar environmental outcomes, but draws what the CHBC regards as an inadequately supported conclusion that transitioning the natural gas system to renewable gas is infeasible based upon optimistic assumptions for electricity costs, pessimistic assumptions for electrolyzer costs**

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[1] 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. 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 Air Liquide Advanced Technologies U.S. LLC.; Alameda-Contra Costa Transit District (AC Transit); American Honda Motor Company; Anaerobe Systems; Arriba Energy; Ballard Power Systems, Inc.; Bay Area Air Quality Management District (BAAQMD); Beijing SinoHytec; Black & Veatch; BMW of North America LLC; Center for Transportation and the Environment (CTE); Charm Industrial; Chiyoda Corporation; Clean Energy Enterprises; Community Environmental Services; CP Industries; DasH2energy; Dominion Energy; Eco Energy International, LLC; EcoNavitas; ElDorado National – California; Energy Independence Now (EIN); EPC - Engineering, Procurement & Construction; Ergostech Renewal Energy Solution; EWII Fuel Cells LLC; FIBA Technologies, Inc.; First Element Fuel Inc; General Engineering & Research; General Motors, Infrastructure Planning; Geoffrey Budd G&SB Consulting Ltd; Giner ELX; Gladstein, Neandross & Associates; Greenlight Innovation; GTA; H2B2 USA; H2Safe, LLC; Hexagon Lincoln; Hitachi Zosen Inova ETOGAS GmbH; HODPros; Hydrogenics; Hydrogenious Technologies; Hydrogen Law; HyET - Hydrogen Efficiency Technologies; HyperSolar, Inc.; Hyundai Motor Company; IGX Group Inc; ITM Power Inc; Ivys Inc.; Iwatani Corporation of America; Johnson Matthey Fuel Cells; KORE Infrastructure, LLC; Kraft Powercon; Life Cycle Associates; Longitude 122 West, Inc.; Loop Energy; Magnum Energy; Manticore Advocacy LLC; Millennium Reign Energy; Mitsubishi Hitachi Power Systems Americas; Motive Energy Telecommunications; Natural Gas Fueling Solutions (NGFS); Natural Hydrogen Energy Ltd.; Nel Hydrogen (US); Neo-H2; Neuman & Esser USA, Inc; New Flyer of America Inc; Next Hydrogen; Noyes Law Corporation; Nuvera Fuel Cells; Pacific Gas and Electric Company - PG&E; Pacific Northwest National Laboratory (PNNL); PDC Machines; Planet Hydrogen Inc; Plug Power; Politecnico di Torino; Port of Long Beach; Powertech Labs, Inc.; Primidea Building Solutions; RealEnergy, LLC; RG Associates; Rio Hondo College; Rix Industries; Sacramento Municipal Utility District (SMUD); SAFCell Inc; Sheldon Research and Consulting; South Coast Air Quality Management District; Southern California Gas Company; Strategic Analysis Inc; Sumitomo Corporation of Americas; Sumitomo Electric; Sunline Transit Agency; T2M Global; Tatsuno North America Inc.; Terrella Energy Systems Ltd; The Leighty Foundation; TLM Petro Labor Force; Toyota Motor Sales; Trillium - A Love's Company; University of California, Irvine; US Hybrid; Valley Pacific Petroleum Services Inc; Vaughan Pratt [Individual]; Verde LLC; Vinjamuri Innovations LLC; Winkelmann Flowform Technology; WireTough Cylinders, LLC; Worthington Industries; YanliDesign; Zero Carbon Energy Solutions.

and no consideration of either partial building electrification through gradual increase in the permissible renewable hydrogen fraction on the gas grid.

2. **Beyond the issue of mixed levels of optimism and risk in the primary scenarios comparisons, coming to reasoned and accurate conclusions on comparative costs between all-electrification and renewable gas scenarios based on a single-case electric cost forecast is technically flawed, in light of the substantial uncertainties, particularly regarding wildfire impacts, on electricity costs. At a minimum, the results should include a robust discussion of the implications of hydrogen costs reaching DOE targets (the low-cost hydrogen case) and electricity rates incorporating properly anticipated wildfire costs.**

3. **Regardless of the extent to which California pursues building electrification, significant gas demand remains in 2050 and beyond in all E3 scenarios, and therefore, examining how to deeply decarbonize the state gas supply with zero carbon gas sources, including hydrogen and its derivatives, is warranted to support the state's climate targets.**

4. **Failing to adequately examine pathways for hydrogen and its derivatives within the full range of potential cost and technology trajectories could impede implementation of several state policies and, more importantly, the environmental goals on which they are based.**

5. **Given uncertainties about future energy costs and the growing body of international research that suggests 90+% greenhouse gas reductions below 1990 levels in industrialized nations will require pursuing several decarbonization pathways at once - including electrification, low-carbon and renewable hydrogen, and other decarbonization approaches - we urge California to adopt a multi-pronged policy approach for decarbonized technology innovation that includes advancing hydrogen as one of a plethora of climate solutions.**

II. Comments

The following comments further elaborate on these points and identify specific questions or concerns with the draft as presented.

A. The cost of electrolyzers on Slide 11 in the presentation labeled as "base-case" is overly pessimistic and should be regarded as a high or worst case.

The base-case electrolyzer costs used for the primary scenarios are too high. Based on the input of CHBC's electrolyzer members and other UCI work presented in a November 13, 2018 Energy

Commission Webinar on their Renewable Hydrogen Roadmap,[2] the costs referenced as "base-case" are more consistent with a high-cost scenario. A reasonable and justifiable cost scenario should be used for electrolyzers.

B. The study does not sufficiently justify how there can be a major increase in electricity demand without an increase in electricity costs or bills in the High Electricity Demand Scenario, yet a significant decrease in gas demand with increased utility bills in the "Mixed Fuel" scenario where gas continues to be used.

On slide 49 of the presentation, there is a graph showing that of the three scenarios considered, the electricity demand will rise to the highest level through 2050 in the High Electrification scenario - about a 50% increase starting in 2030 – with only a modest increase in both the reference case and the SNG/no electrification cases. Another graph on the same slide shows that in the High Electrification scenario, electricity rates will also remain essentially flat through 2050. This assumption is questionable because extensive and costly work would be required on the electricity grid to accommodate a transition to all or mostly electrification, and ratepayers would presumably have to pay for this work. On slide 54, a graph shows that electric utility bills will remain flat through 2050 in the High Electrification Scenario after a slight decrease around 2030, but in a Mixed Fuel (gas and electric) scenario, bills will increase. Even if the electricity rates did stay flat in the High Electrification scenario, it is not logical that customers would be using roughly 50% more electricity without paying higher electricity bills. E3 must address this gap in logic.

The study assumes that if gas continues to be used (presumably in the form of renewable gas) in conjunction with electrification (i.e. "Mixed Fuel" scenario), Mixed Fuel customer bills will increase (slide 54), in spite of a decrease in gas consumption as much as 80% through 2050 because of efficiency and SB 100 (slide 52). There needs to be an evidence-based explanation of how an increase in electricity demand leads to the unlikely scenario of flat electricity bills on the electric side, but a decrease in gas demand leads to an increase in utility bills on the gas side.

C. Current uncertainty around wildfires, utility liability, and associated ratepayer impacts make it difficult, if not impossible to compare future gas and electricity rates, and alternate pathways dependent on them, in any reliable way.

The PATHWAYS model is not designed to compare technologies against each other, as much as it is to compare costs, based on a set of input assumptions, for different scenarios to meet the state's climate targets. In this particular exercise, a primary element of the analysis and conclusions rests on assumptions about relative utility rates for natural gas and electricity. The

[2] See *Comments Presentation - Renewable Hydrogen Roadmap Progress Report to Stakeholders* by Jeffrey Reed, PhD. https://efiling.energy.ca.gov/getdocument.aspx?tn=225080

analysis recognizes that electricity rates are "uncertain," but models a 6-8% increase over the next 4 years (compared to an assumed 15-30% increase for natural gas rates). "Uncertain" is an understatement relative to electricity rates right now, given utility bankruptcy and uncertain liabilities. Electricity rates may rise by at least three times more than the levels assumed in the E3 model over the next four years.[3] In fact, the only thing certain about electricity rates right now is that they will remain highly uncertain until the legislature acts to address wildfire liability, and perhaps even beyond that, if inverse condemnation[4] is not addressed, which threatens "customers' access to affordable energy and clean water."[5]

It is also important for policymakers to bear in mind the fact that the costs to Californians of wildfires are not limited to electricity rates. The State Insurance Commissioner gave an early estimate of over $9 billion in insured losses from the 2018 fires alone.[6] Additional losses of unknown amounts are being incurred by many Californians who are under-insured, which likely represents most homeowners who lost their homes.[7] Furthermore, there are costs associated with public health from exposure to smoke and other deleterious stressors caused by fire. During the 2018 Camp Fire, air pollution reportedly exceeded world health standards by 60 times.[8] Additionally, there are questions about reliability and safety concerns, given the vulnerability of the electricity grid with respect to wildfire.

Other types of disastrous events to which the state is prone, such as earthquakes, also must be factored into the analysis, and all types of energy infrastructure have vulnerabilities to consider.

D. It is also worth noting that both pipeline injection of renewable gas and building electrification remain nascent markets in California, and there remains significant uncertainty about how those markets will grow and associated costs – both in the near and long term.

This makes drawing conclusions based on presumed costs of these technologies today a difficult, if not baseless, exercise. That said, one of the most valuable aspects of modeling tools is to better explore risks and tradeoffs of unknown futures, based on a range of assumptions. For example, rather than comparing two discrete scenarios in the draft results (high electrification with no hydrogen and no electrification with hydrogen), and basing conclusions on them, policymakers should ask to see a range of assumptions about costs and other

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[3] https://www.wsj.com/articles/california-girds-for-higher-power-prices-from-pg-e-after-fires-11544706001

[4] Inverse condemnation is a legal concept used in California that allows the public to seek being awarded for damages caused by entities providing a public benefit (such as utilities do for providing electricity) regardless of whether that entity behave negligently. There is discussion underway in California about changing this doctrine in the wake of recent wildfires.

[5] Wildfire Commission (2019) Draft Executive Summary, June. http://opr.ca.gov/meetings/wildfire-commission/2019-06-07/docs/20190607-Item_7_Wildfire_Commission_Executive_Summary_Discussion_Draft.pdf

[6] http://www.insurance.ca.gov/0400-news/0100-press-releases/2018/release142-18.cfm

[7] https://www.pbs.org/newshour/economy/making-sense/californias-wildfire-victims-could-be-like-most-homeowners-underinsured

[8] https://www.bloomberg.com/technology

performance characteristics within each of those scenarios, before drawing conclusions that one technology or approach is likely to lead to a lower cost clean energy future than another.

E. The authors' presentation of "Components of a Gas Transition" on Slide 27 covers approaches and cost-sharing leading to a gradual winddown and shutdown of the natural gas system, but this entire analysis is premature because it lacks analyses for the potential of transitioning the natural gas system to higher hydrogen fractions and in the context of a 100% decarbonized electricity mandate.

This slide suggests that a gas transition inherently means eventually shutting down the gas system. Optimizing the gas grid, as well as enabling the transition to a 100% renewable and zero carbon electricity supply, by transitioning to decarbonized gas including hydrogen, including the impacts on technology costs, ought to be more deeply investigated before jumping to this conclusion. Such an approach is being extensively studied in Europe (see Item K, e.g.), with numerous hydrogen related projects being pursued across the continent.[9] We encourage the Energy Commission to pursue a similar approach. There is a danger that this slide will be taken as proof that the gas system should be shut down, which would be an inaccurate reflection of the data and based simply on the observation or opinion of E3.

F. The underlying basis and assumptions on gas revenue requirements used for the chart on Slide 28 require greater explanation.

The chart shows impacts on gas revenue requirements under three scenarios - electrification, no gas retirements, and gas network expansion. Back-up and substantiation of the assumptions are needed.

G. Regardless of assumptions about building electrification, significant gas demand remains in 2050 and beyond in all scenarios, and there is a clear role for renewable gas, including hydrogen and its derivatives, to meet the state's climate targets.

In all of E3's decarbonization scenarios, no matter what the assumptions are about building electrification or strategies to reduce emissions in any sector, there remains significant demand for gas, in fact, higher than the amount of gas used today by all but about the 5-15 biggest gas consuming states in the US[10] along with renewable gas through at least 2050. As long as gas demand persists for several decades to come or beyond, it only makes sense to plan to decarbonize it, like any other sector.

[9] For map of European power to gas projects, please see: http://europeanpowertogas.com/projects-in-europe/

[10] Based on the results presented in Slide 52, it appears that gas demand in California across the set of deep decarbonization scenarios explored ranges from about 600-1300 TBtu in 2050, which exceeds current gas demand in the vast majority of US States, as shown here: https://www.eia.gov/dnav/ng/ng_cons_sum_a_EPG0_VC0_mmcf_a.htm

All three scenarios on Slide 16 show reliance on renewable gas through 2050, along with all ten deep decarbonization scenarios modeled for the CEC in June 2018 (see Appendix). If California were to aim to transition the fossil-based gas entirely to zero carbon sources, this could be done by expanding hydrogen, and particularly electrolytic hydrogen and derivatives, due to their scalability and flexibility. As the power grid completely decarbonizes by 2045, per SB 100's mandate, the gas grid could decarbonize in parallel, helping to advance carbon neutrality or negativity economy wide, as called for by Executive Order B-55-18. Economies of scale could bring down the price of electrolysis and other renewable gas technology, and assets associated with renewable gas development could be assured of not becoming stranded, since they are likely to exist at least through 2050. E3's slide presentation ought to at least acknowledge that the cost results for hydrogen would change significantly under a scenario of a zero carbon gas supply.

H. We are concerned that by falling short of its obligation to accurately consider the role of decarbonized gas, including low carbon and renewable hydrogen, from sound data, E3 's presentation and inferred conclusions might impede implementation of several California mandates and policies that support hydrogen and other decarbonized gas development, such as those listed below, as well as make it more difficult for and the Energy Commission to realize the full potential of its investment and policy direction related to hydrogen.

- ***Executive Order B-48-18*** calls for the expansion of hydrogen fueling stations to enable the state's goal to put 5 million zero emission vehicles on California roads by 2050.

- ***AB 8*** further calls for funding of hydrogen fueling infrastructure for transportation.[11] A recent Joint Agency report on AB 8, predicts a shortfall of hydrogen supply to keep up with ZEV fueling demand by 2020, underscoring the need to scale production.[12] Although in the long-term future, dedicated hydrogen pipelines will likely be the most cost-effective solution for transporting the fuel, in the near term, existing natural gas infrastructure can serve a critical role in the hydrogen supply chain, and hydrogen blends will likely be part of the gas supply over the long term as well. A shut down of gas infrastructure, as could be interpreted as the recommendation of the E3 presentation, would preclude this opportunity.

- ***SB 1505*** further mandates that a third of hydrogen for transportation fueling in California come from renewable sources.[13] Any production pathways may show

[11] Bill text: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB8
[12] http://www.energy.ca.gov/2017publications/CEC-600-2017-002/CEC-600-2017-002.pdf , p. 3
[13] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200520060SB1505

improved economics through transport over the natural gas common carrier gas system in various use cases. Currently, the hydrogen industry has surpassed the state's 33% renewable mandate,[14] and the CHBC supports the Hydrogen Council's goal of achieving 100% decarbonized hydrogen for transportation by 2030.[15] To enable more renewable hydrogen in-state, which the hydrogen industry wants and would provide California the full emissions and jobs benefits of renewable hydrogen, it is essential to create well-formed and supportive regulatory frameworks. Today, the first generation of renewable hydrogen production facilities are under development in the state, including a 100% renewable hydrogen production facility in Moreno Valley, Riverside County, scheduled to begin production in 2020 that is **funded by the Energy Commission** and will use dedicated renewable generation to power a 2.5 MW electrolyzer to produce hydrogen.[16] There are also several other projects proposed or announced in the Energy Commission solicitation, along with other projects that have not been publicly announced. To build on this substantial investment by the state and many companies and achieve economical production of renewable hydrogen for consumers, California needs to continue to support the nascent renewable hydrogen industry, not send a chilling effect by issuing a study that suggests it may have little to no future in the state.

- ***Federal and State clean air standards***, which regions throughout California chronically fail to attain, risk continuing to go unmet without hydrogen fuel cell electric technology, which is a key component of the state's Mobile Source Strategy to resolve its pernicious air pollution problem.[17]

- ***SB 1383*** is a landmark piece of legislation that requires California agencies "to consider and, as appropriate, adopt policies and incentives to significantly increase the sustainable production and use of renewable gas" as a strategy for decreasing short lived climate pollutants.[18] Notably, the author of SB 1383 ensured CHBC Members that the broad language "renewable gas" was chosen, so that renewable hydrogen would be included in all relevant deliberations. The Energy Commission's ***2017 Integrated Energy Policy Report*** reinforces this in its discussion on implementing SB 1383, explicitly including renewable hydrogen in the suite of solutions California deploys to mitigate

[14]As reported by CARB Staff to CHBC and published in *Zero Emission Transportation and Power The Opportunity of Hydrogen Energy*, CHBC, January 2018 https://www.californiahydrogen.org/wp-content/uploads/2018/03/CHBC_Opportunity-of-Hydrogen-and-Fuel-Cells-January-2018.pdf
[15] https://www.californiahydrogen.org/2018/12/20/chbc-endorses-full-decarbonization-goal-of-hydrogen-in-transportation-by-2030/
[16] This project is being developed by Hydrogenics and StratosFuel with funding from the Energy Commission.
[17] https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf
[18] SB 1383 text: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1383

short lived climate pollutants.[19] Remarkably, the E3 presentation makes no mention of either short lived climate pollutants or SB 1383.

- ***SB 100*** calls for investor owned utilities to procure 60% RPS eligible renewable electricity, which along with large hydro and rooftop solar, will make California's electricity mix predominantly supplied by variable renewables as soon as 2030, if not before. By 2045, electricity generation must by law be 100% renewable and zero carbon. As renewable generation and electrification reaches high levels, long duration and seasonal storage will soon become critical. According to a report from the European Association for Energy Storage, electrolytic hydrogen based solutions are *"the only energy storage option available to store large amounts of energy seasonally and provide it on-demand to different sectors and applications."*[20] Electrolytic hydrogen produced using renewable electricity and renewable methane derived from electrolytic hydrogen, if they have access to the gas system for transportation and long-term storage, not only can provide what may be the only feasible pathway to achieve energy storage at the terawatt-hour scale and for up to a year, but also have the added benefit of being far more geographically flexible than other bulk storage technologies, such as pumped hydro and compressed air.[21] According to a presentation by UCI, moreover, there is not enough cobalt or lithium in the world to supply California's storage needs with batteries alone.[22] Meanwhile, electrolyzers and fuel cells do not require rare metals or other materials in limited supply, with the exception of platinum, which is, as a major cost component, decreasing considerably with every new generation of products.[23] Underscoring electrolytic hydrogen's potential value to integrating renewables, the ***2017 Integrated Energy Policy Report*** **(IEPR)** calls for California to explore converting renewable electricity to hydrogen as a strategy for managing excess renewable generation.[24] **The CEC 2018 IEPR Update** explicitly adds that *"(t)he SB 100 reporting requirement requires analysis in upcoming IEPRs. A near-zero-carbon electricity sector will require continued integration of mature renewable generation technologies, very likely under higher-than current load conditions, but also the development of resources such as renewable gas, including power-to-gas and renewable hydrogen. Staff discussed these resources and presented estimates of the related future costs in the 2017 IEPR and will do so again in the 2021 IEPR in support of the joint agency report to the*

[19] See, e.g., 2017 IEPR pp. 260, 280, 285-286.

[20] http://ease-storage.eu/wp-content/uploads/2017/05/2017.05.15_EASE-Recommendations-PtG-PtL_final.pdf

[21] See CHBC's submission to the 2017 IEPR Report Comments titled *Economics of Power-to-Gas.*

[22] *The Scientific Imperative for Hydrogen and Fuel Cells,* Dr. Jack Brouwer, UCI National Fuel Cell Research Center, Nov. 6, 2018

[23] https://www.reuters.com/article/us-platinum-fuelcells-analysis/platinums-fuel-cell-car-bonanza-proves-elusive-idUSKCN1GL1DG

[24] See 2017 IEPR Ch. 3 Recommendations, p. 120

Legislature."[25]

- ***SB 1369*** directs California agencies like the CPUC to examine green electrolytic hydrogen as a storage source and for other potential beneficial uses.

- **Executive Order B-55-18** calls for California to be carbon neutral economy-wide by 2045 and carbon negative thereafter. Continuing to rely significantly on fossil natural gas beyond that date, as all the E3 scenarios presented propose, could impede achieving that goal.

I. Inadequate consideration of hydrogen solutions also is in contrast to the recommendations of national and international energy research and policy frameworks, which are calling for renewable hydrogen and its derivatives as core elements of approaches to achieve deep decarbonization or carbon neutrality/carbon negativity across sectors.

North America/United States – Part of the U.S. Department of Energy's multi-sector approach to developing advanced energy solutions is its H2 @ Scale Initiative, which is committed to exploring the potential for wide-scale production and utilization of hydrogen in the U.S. to foster grid resiliency, jobs, and other benefits. Demonstrating its continued commitment, the program recently announced $31 million of funding to research and develop electrolytic hydrogen for multiple applications.[26] Showing that advancing hydrogen carries bipartisan support nationally, both of the former U.S. Department of Energy Secretaries under President Obama are focusing on renewable hydrogen as a key component of their continued effort to build a clean energy future. Secretary Chu advocates for storing electrolytic hydrogen produced with renewables in underground resources, in order to overcome the limitations of batteries to supply the scale of storage needed in a climate safe future.[27] He also recently forecast that the falling cost of renewable electricity holds promise to make renewable electrolytic hydrogen cost competitive with hydrogen produced with natural gas.[28] Secretary Moniz recently oversaw a report that identified hydrogen as among the handful of "breakthrough technologies" that are "major potential contributors to California's deep decarbonization over the long-term," adding that "(t)he work must pick up the pace today and be sustained to support their development."[29]

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[25] P. 88, 2018 IEPR Update Volume II, California Energy Commission
[26] https://www.energy.gov/eere/fuelcells/h2scale
[27] *Obama Secretary Flat on Battery Plants, The Australian*, February 1, 2018
[28] *Get Ready For 1.5¢ Renewable Electricity, Steven Chu Says, Which Could Unleash Hydrogen Economy,* Jeff McMahon, *Forbes*, April 2, 2019
[29] *Optionality, Flexibility, and Innovation – Pathways for Deep Decarbonization in California*, Energy Futures Initiative (Secretary Ernst Moniz, Founder & CEO); April 2019

Large scale hydrogen projects are starting to be realized in North America, with a 1 GW storage project that will include hydrogen storage announced just last month to be under development in Utah.[30] A 2.5 MW electrolytic hydrogen storage project is also already up and running in Ontario Canada, procured by the national transmission grid operator to help integrate renewables and stabilize the grid.[31]

European Union - The European Commission issued an extensive report in November 2018 examining pathways to greenhouse gas neutrality for the European Union, which looked at eight scenarios and found that the only ways to achieve deep decarbonization of 90+% greenhouse gas emissions below 1990 levels by 2050 involve aggressively pursuing diversified approaches that focus not only on electrification nor decarbonized gaseous fuels like hydrogen, SNG, or bio-based gas alone, but rather all of the above, along with efficiency, a circular economy, and smart technologies, and that net carbon neutrality by 2050 and net negativity thereafter would require this same strategy, in addition to additional carbon capture or advanced management of land sinks.[32]

We recommend California look closely at comprehensive, science-based examples like the European Union scenarios and adopt a similarly in-depth, holistic approach to analysis, rather than framing the debate between electrification and renewable gas, which we believe sets up an oversimplified false choice, as previously described. To ensure California continues to remain on the vanguard of global climate leadership, we urge California as a separate but related effort, to adopt diversified approaches to investigating deep decarbonization strategies that, like the European Union's, pursue multiple pathways to decarbonization, including electrification *and* a wide range of renewable gases and fuels, such as renewable hydrogen and its derivatives, among other promising tools.

Asia – **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.[33] Showcasing this

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[30] https://www.greentechmedia.com/articles/read/utah-aims-to-shatter-records-with-1000-mw-energy-storage-plant#gs.iwx5ic

[31] https://www.hydrogenics.com/2018/07/16/north-americas-first-multi-megawatt-power-to-gas-facility-begins-operations/

[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.

[33] https://www.meti.go.jp/english/press/2017/pdf/1226_003a.pdf

ambition, the 2020 Olympics in Japan aims to run entirely on hydrogen. A report prepared for Japan by the International Energy Agency declares: "*This is a critical year for hydrogen. It is enjoying unprecedented momentum around the world and could finally be set on a path to fulfill its longstanding potential as a clean energy solution. To seize this opportunity, governments and companies need to be taking ambitious and real- world actions now*."[34] California ought to avoid the opposite pathway of inaction.

In **China**, the "father" of China's electric vehicle industry and vice chairman of China's national advisory body for policy making, Wan Gang, who convinced Chinese leaders twenty years ago to adopt battery electric vehicle technology, is now saying the country should be looking into "establishing a hydrogen society" and is seeking to have China similarly become a global leader in developing hydrogen technology.[35]

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.[36]

Hydrogen is also gaining interest in the **Middle East**, and a multi-megawatt solar hydrogen project has broken ground in Dubai,[37] among other projects.

Hydrogen is also on the national agenda of **Australia**. The nation'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."[38] By 2030, it is estimated that the Australian hydrogen industry could be worth over a billion dollars and provide 2,800 jobs.[39] Notably, a 2017 study by the Australian Gas Infrastructure Group, with input from Deloitte, comparing an electrification to a hydrogen conversion pathway to decarbonizing the state of Victoria's gas consumption found that although costs of long-term hydrogen storage need to be better understood, modeling showed that the hydrogen conversion pathway would cost about 40% less than the full electrification pathway. This is largely because of the flexibility of electrolysis to meet gas

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[34] P. 1, *The Future of* Hydrogen, *Seizing Today's Opportunities, Executive Summary and Recommendations,* IEA, June 2019 https://webstore.iea.org/download/summary/2803?fileName=English-Future-Hydrogen-ES.pdf

[35] https://www.supplychainbrain.com/articles/29843-chinas-father-of-electric-cars-says-hydrogen-is-the-future

[36] p. 56, *Hydrogen for Australia's Future,* Hydrogen Strategy Group (Chaired by Australia Chief Scientist, Dr. Alan Finkel); August 2018

[37] https://gulfnews.com/uae/first-green-hydrogen-project-breaks-ground-in-dubai-1.1549175502065

[38] p. i, ibid.

[39] p. 12, Ibid.

demand, lower long-term requirement for electricity storage though batteries or hydro, and lower network upgrade costs because of the use of the existing gas infrastructure.[40]

J. It would be appropriate for the E3 report to incorporate peer review and/or reviewer comments into the final draft of the report and presentation, and clearly distinguish opinion from analytical results.

To ensure analytical rigor and transparency, we encourage the Commission to ensure that the report is peer reviewed and to incorporate review comments into the final draft to the extent that the analysis is not modified to address those comments. The report should also clearly distinguish analytical results from their opinions when presenting implications of the Pathways results.

III. Conclusion

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

Sincerely,

Emanuel Wagner
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[40] Ibid, p. 30

IV. Appendix

We understand that the results presented at the workshop are a preliminary presentation of study results and that a full narrative report will be published in the future. However, we find it important to comment on the information and conclusions presented because of the major policy implications of the conclusions and analysis presented. As noted in the opening slide, the work presented relies on prior work performed by E3 under Energy Commission sponsorship (the "Deep Decarbonization in a High Renewables Future" study that E3 completed and published by the Energy Commission in 2018.[41]). Given the greater supporting detail in that report and the fact that it underpins the current one, our comments in this Appendix also refer to results of the prior work in comparison to the current preliminary results.

A. E3's 2018 scenarios show that GHG benefits occur earlier in high-renewable gas scenarios than in high-electrification scenarios.

While the details of the 2018 scenarios are not laid out fully in the June 6, 2019 slide presentation, they appear to derive from, and presumably are very similar to (if not identical in many respects), a set of scenarios developed for the CEC in 2018, showing 10 different scenarios for meeting California's greenhouse gas emissions goals in 2030 and 2050.[42] Two scenarios from E3's most recent report to the CEC are particularly informative here.[43] "CEC 2050" is their primary scenario presented (and perhaps evidentiary of pre-disposed biases) and assumes very high rates of building electrification. An alternate scenario, "CEC 2050 No Heat Pumps Plus" explicitly excludes heat pumps while including power-to-gas as a strategy to reduce emissions from buildings and other sectors. Annual emissions from the "Residential and Commercial" sector are lower in "CEC 2050 No Heat Pumps Plus" than they are in "CEC 2050" through 2033, at which point cumulative emissions from the sector from 2019-2033 are 20 MMTCO2e lower in "CEC 2050 No Heat Pumps Plus" than they are in "CEC 2050." After 2033, annual emissions from the "Residential and Commercial" sector are lower in "CEC 2050," but not until 2039, 20 years later, do cumulative emissions from buildings in the case with high electrification actually fall below levels achieved in the case without heat pumps and with power-to-gas. Furthermore, cumulative emissions from 2019-2050 in the electric power and industrial sectors, combined, are 68 MMTCO2e lower in "CEC 2050 No Heat Pumps Plus" than they are in "CEC 2050."

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[41] https://www.ethree.com/projects/deep-decarbonization-california-cec/

[42] E3 report on "Deep Decarbonization in a High Renewables Future," June 2018, CEC-500-2018-012. https://www.ethree.com/projects/deep-decarbonization-california-cec/

[43] See: "PATHWAYS model: Summary and comparison of scenario results" at https://www.ethree.com/projects/deep-decarbonization-california-cec/

To the extent that a priority for supporters of building electrification stems from a desire to reduce greenhouse gas emissions by reducing demand for natural gas, it is not borne out by the scenarios. Both scenarios lead to significant and similar reductions in fossil natural gas use. However, natural gas use is actually lower in the renewable gas case without heat pumps – on an annual basis through 2041, and cumulatively through 2050 (see Figure 1 below).

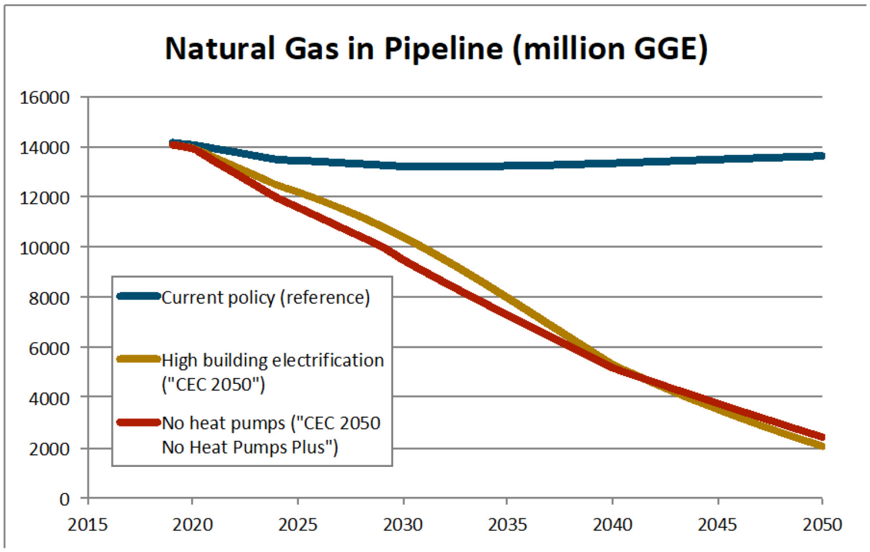

Figure 1. Annual natural gas demand in previous scenarios E3 developed for CEC in June 2018.[44] In the high building electrification case ("CEC 2050") annual natural gas demand is higher through 2041, and cumulatively higher from 2019-2050, than it is in a scenario with no heat pumps that utilizes power-to-gas to help decarbonize buildings and other sectors.

B. Renewable gas offers the most certain level of emissions reductions among options to decarbonize gas end uses. The emissions impacts of electrifying building appliances, while promising, are uncertain, and require matching new electricity load from electrified buildings with clean electricity generation to ensure emissions reductions.

While the emissions benefits of electrification are dependent on evolving and dynamic grid conditions, displacing fossil gas with renewable gas or hydrogen leads to definite emissions reductions, which may partially explain the difference in building sector emissions discussed in K. In particular, electricity sector emissions tend to be highest during the shoulder hours (sunrise and sunset) and overnight, and during winter and other non-spring months. This tends to be when new electricity demand for things like cooking, space heating, or water heating would occur. Electricity sector emissions are lowest during work hours and spring months, when demands for new electricity would likely be lower. Indeed, EIA data shows that half of all residential gas demand occurs in winter months, when demand is up to ten times higher than

[44] See: "PATHWAYS model: Summary and comparison of scenario results" at https://www.ethree.com/projects/deep-decarbonization-california-cec/

summer demands.[45] And previous work by E3 estimates that all-electrified homes could have 2-3 times higher electricity demand during the early morning hours of winter months (peaking around 7am), with virtually no difference in electricity demand between the two building types during summer months.[46]

As the grid gets cleaner, so too will electrified buildings, and emissions reductions from electrified appliances will become more certain. This may take time, however. For example, a report by the Building Decarbonization Coalition cites CEC analysis showing that in general, appliances or end uses using electricity from approximately 8 or 9pm at night through approximately 7am in non-spring months will have higher emissions in 2030 than those same end uses using conventional natural gas (see Figure 2).

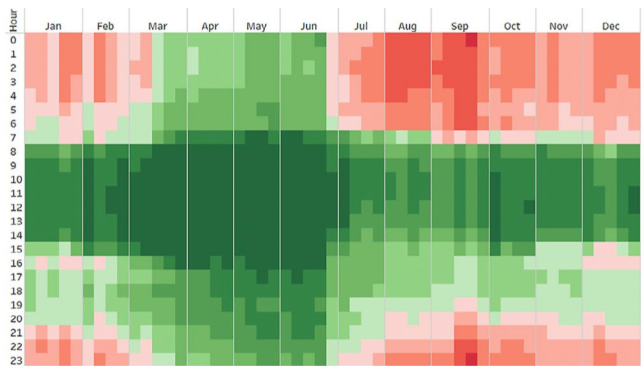

Figure 2. Emissions intensity relative to natural gas in 2030.[47] Red hours indicate when electrified appliances would increase emissions, relative to appliances using fossil natural gas. Green hours indicate when emissions would be lower

Over the next ten years, before 2030, there will be even more hours when electrification could increase emissions. For example, as part of its IEPR, CEC estimates average grid emissions factors for various demand scenarios in 2019 and 2030. In CEC's Mid Demand case, average grid emissions factors are about 30 percent higher in 2019 than 2030,[48] suggesting electrification would increase overall greenhouse gas emissions during many more hours in the near-term than illustrated in Figure 2. As further example, if hour 21 of January in 2030 (see Figure 2) is used as the threshold for when electrification might reduce emissions, electrification would then increase emissions in 70 percent of all hours in 2019, based on the average emissions factors in the IEPR projections.[49]

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[45] https://www.eia.gov/todayinenergy/detail.php?id=22892
[46] https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf
[47] http://www.buildingdecarb.org/resources/a-roadmap-to-decarbonize-californias-buildings (page 9)
[48] https://efiling.energy.ca.gov/getdocument.aspx?tn=224499
[49] Ibid

Certainly, electrified buildings offer deep emissions reductions potential in the long-term, especially as the state moves toward 100 percent clean energy in 2045. In the near-term, however, those reductions are less certain. Supporting renewable gas development alongside any building electrification strategy the state may pursue would lead to more certain outcomes and greater emissions reductions in the near and long-term.