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Comments of the National Fuel Cell Research Center

Additional submitted attachment is included below.

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California Energy Commission
MS Dockets Office, MS-4
Re: Docket No. 17-IEPR-10
1516 Ninth Street
Sacramento, CA 95814-5512

Re: IEPR Renewable Natural Gas Plans for Renewable Fuel Cell Applications

The National Fuel Cell Research Center (NFCRC) submits these comments on the Renewable Natural Gas (RNG) Docket #17-IEPR-10 of the California Energy Commission's (CEC) Integrated Energy Policy Report (IEPR) to affirm and emphasize the importance of recognizing GHG-reducing fuel cells as a critical technology needed to complement and manage the high penetration of intermittent solar and wind, cornerstones in achieving the California 40% GHG emissions reduction goal by 2030.

Emissions Mitigation
Fuel cells address simultaneously the mitigation of CO_2, criteria air pollutants, and short-lived climate pollutants[1] – co-benefits which are all direct or indirect goals of integrated energy and resource planning in California.

For CO_2 reduction, the high fuel-to-electrical efficiency of fuel cells significantly reduces the carbon emitted per megawatt-hour, and fuel cells have the capability to capture, concentrate, and store the resulting CO_2 that is generated. The unusually high operating temperatures of fuel cells enables the cogeneration of heat, steam, or chilled water, thereby displacing conventional carbon emitting sources such as grid electricity, natural gas boilers, and natural gas furnaces. Fuel cells are operating today on biogas, further contributing to the management of carbon. Therefore, fuel cells represent an immediate benefit that may be further expanded as the market for biogas evolves to make cost-effective and accessible renewable biogas supplies widely available. In the future, with the supply of renewable hydrogen evolving as the principal strategy to capture and store energy that would otherwise be curtailed, fuel cells will operate directly on renewable hydrogen to complement and manage the intermittency of solar and wind. The fuel cell will be a firm (24/7) 100% load-following renewable generator.

For criteria air pollutant reductions, fuel cells have the distinct attribute of emitting virtually zero criteria pollutants.

[1] *Final Report: SGIP 2014-2015 Impacts Evaluation Report.* Submitted by Itron to SoCalGas and the SGIP Working Group, September 29, 2016.

For short-lived climate pollutant reductions, fuel cells are an ideal technology to mitigate emissions because fuel cells:

- Can generate electricity and heat from methane sources otherwise vulnerable to seepage such as landfills, water resource recovery facilities, refineries and dairies.
- Are today capturing and using exhaust heat to produce chilled water, thereby displacing traditional chlorofluorocarbons (CFC)-based systems and the associated leakage.

Renewable Gas Resources

Over 30% of the power generated by fuel cells in California today is sourced from biogas. When operated on biogas, fuel cells generate electricity and heat (and bio hydrogen if appropriately configured), with zero net carbon emitted. Fuel cells are also capable of operation on renewable hydrogen in response to the evolution of a supply of renewable hydrogen associated with the generation, storage, and utilization of wind and solar power that would otherwise be curtailed. As a result, the exportability of stationary fuel cell technology is ubiquitous across a spectrum of applications associated with a zero-carbon grid. In addition, the energy density of fuel cell systems significantly reduces the land footprint required for onsite generation allowing for deployment in high density areas and increased acreage available for habitat restoration and preservation. When operated on renewable hydrogen in the future, fuel cell systems will produce complementary, dispatchable power with zero greenhouse gas and zero criteria pollutant emissions.

Today, renewable hydrogen costs more than hydrogen produced from present methods, including steam methane reformation (SMR) of natural gas. Currently, renewable hydrogen produced from directed biogas via central SMR is the next lowest cost option and used today to fulfill the California requirement that 33% or more of the hydrogen dispensed be renewable. Hydrogen from electrolysis using renewable electricity is not currently cost competitive, but is likely to become cost competitive when renewable power in the future becomes universal or would otherwise be curtailed.

To mitigate cost increases to consumers, biogas projects within and outside of California should be immediately pursued. The potential of biomass pathways for the production of hydrogen should also be considered since they potentially lie between electrolysis and biogas supply chain costs. Note that, while the CEC has recently released $36M (15-606: biofuels) and $23M (15-325: biomass to energy) plus federal cost share for biofuel projects, none of these projects include a hydrogen production pathway even though some of the considered technologies could be utilized in such a manner. Additionally, waste/residue biomass resources should be used to maximize the offset of GHG emissions, which would most likely occur from the production of fuel for the transportation sector.

In summary, the production of hydrogen from biogas resources represents the most cost-effective and technologically mature pathway for renewable hydrogen in the near-term. While available biogas resources in California are limited, wastewater treatment plants, water resource recovery facilities, agricultural sources including dairies, and landfills provide an immediate opportunity for meeting short- and medium-term sources for renewable hydrogen. While biogas pathways such as tri-generation are commercially viable, biomass-to-hydrogen pathways require further advancement prior to commercialization, however they can contribute important amounts of renewable hydrogen in the mid-to long-term.

The Intersection of Stationary and Transportation Power Sources
Fuel cell use in transportation applications will enable the additional utilization of renewable hydrogen in zero emissions transportation applications. Fuel cell technology in transportation will be especially needed in applications where rapid fueling, long range or large payloads are required. This is the case for the medium and heavy-duty transportation sectors for which electrification and battery energy storage are not well-suited. The goods movement sector, for example, which has a myriad of these needs and which disproportionately impacts the health of certain communities, could widely use and greatly benefit from fuel cell technology utilization.

The ports of California face both challenges and opportunities in managing and meeting future energy and public health requirements. Currently available transportation and stationary fuel cell technologies can facilitate meeting future energy requirements and contribute co-benefits to port energy and environmental goals,[2, 3] and goals of the environmental justice community. Power generation can be provided at various magnitudes by solid oxide fuel cells (SOFC), molten carbonate, and phosphoric acid fuel cell systems, while combined cooling, heat, and power applications from the same systems can further enhance environmental and energy benefits, and reduce costs. Tri-generation systems that produce on-site hydrogen, electricity, and high quality recoverable heat represent an application that can support both port operations and customer requirements. In contrast to other combustion-based, self-generation technologies, fuel cells have the benefits of zero local pollutant emissions, very low GHG emissions, zero-emission of short lived climate pollutants, and virtually net zero water consumption.[4]

As an example, the Port of Long Beach (POLB), located in the South Coast Air Basin of southern California, generates high levels of health damaging air pollution that leads to degraded air quality in the region. The deployment of GHG-reducing stationary fuel cell systems provides a means of distributed self-generation for the POLB without additional local emissions from port operations.[5] This key co-benefit is unique to fuel cells because other combustion-driven self-generation methods, such as natural gas turbines and reciprocating engines, have pollutant emissions which produce air quality and permitting challenges. The use of fuel cells for stationary power provides a path for the POLB to secure its resilient energy island future while reducing local criteria pollutant emissions that provide improvements in regional air quality, with health benefits to disadvantaged communities in the surrounding area. Specifically, reductions in pollutants will assist the POLB in meeting goals established under the San Pedro Bay Ports Clean Air Action Plan[6] and the Green Port Policy. [7, 8]

Tri-generation fuel cell systems can operate on biogas and other renewable fuels to generate renewable electricity, high quality waste heat, and hydrogen. The technology is based on a high-temperature fuel cell that internally reforms biogas (or natural gas) to hydrogen to support the generation of electricity at the stack and heat in the exhaust. By injecting more fuel, excess hydrogen is produced that can then

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[2] *Requirements at the Port of Long Beach.* MacKinnon, M and Samuelsen, S. Advanced Power and Energy Program, University of California Irvine, April 31, 2016.
[3] *Assessment of Fuel Cell Technologies to Address Power Requirements at the Port of Long Beach*. MacKinnon, M and Samuelsen, S. Advanced Power and Energy Program, University of California Irvine, June 28, 2016. http://polb.com/environment/energyisland.asp
[4] Ibid.
[5] Ibid.
[6] http://www.cleanairactionplan.org/
[7] http://www.polb.com/environment/green_port_policy.asp
[8] *Assessment of Fuel Cell Technologies to Address Power Requirements at the Port of Long Beach.* MacKinnon, M and Samuelsen, S. Advanced Power and Energy Program, University of California Irvine, June 28, 2016.

be extracted as a transportation fuel, or other use. Due to the synergies captured by the process, tri-generation systems afford many economical, technical, and environmental benefits. For example, UCI researchers have calculated that tri-generation can produce distributed hydrogen at costs below that of current methods (i.e., large-scale natural gas steam methane reformation).[9,10] Similarly, the high efficiency allows tri-generation systems to achieve the lowest emissions of greenhouse gasses (GHG), accounting for off-sets from energy stream utilization. When operating on biogas the result is renewable, bio-hydrogen. The technology fits the growing California hydrogen fueling network and, due to these benefits, the use of tri-generation systems should be proactively pursued.

Other Uses of Renewable Natural Gas

The NFCRC supports the IEPR initiative to increase the utilization, and thus availability, of renewable natural gas from biogas. One of the major attributes of fuel cells is the capability to operate on biogas sourced from water resource recovery facilities, landfills, food processing plants, confined animal feeding operations (CAFOs), and other sites processing organic waste via anaerobic digestion. An important component to a sustainable future is the availability of biogas, and the infrastructure to utilize the biogas in the State of California. A recent report from the California Energy Commission has mapped the biogas resources in the state and the pathways for the utilization of the biogas[11] and its many associated co-benefits. Fuel cells represent a key clean technology for the utilization of the biogas and the production of renewable electricity and heat, and (as appropriate) the generation of bio-hydrogen. New research and development initiatives, focused on the development of biogas resources and infrastructure, should be implemented.

To address the current challenge of the high cost of renewable hydrogen, strategies to significantly increase demand and thereby reduce costs via economies of scale should be pursued in California. This could be particularly important for reducing the cost of hydrogen produced from renewable electrolysis. This may require outside of the box thinking (i.e., not just a focus on increasing light duty vehicle FCEV demand, but also supporting and investigating the use of hydrogen as a fuel in heavy duty trucking, port operations, shipping, aircraft, and rail applications). Additionally, the CEC should consider encouraging the use of renewable hydrogen in various industrial applications. Examples for increasing the current demand for renewable hydrogen production and consumption include (1) petroleum refinery use of renewable hydrogen to meet a portion of their current demand (hydrogen is widely used by refineries to produce petroleum distillate fuels), and (2) industrial end-uses of renewable hydrogen, such as metal sintering, annealing, and welding, powering life-support systems and computers in space environments, and the production of plastics and pharmaceuticals.

While biogas and biomass provide short-term resources of renewable hydrogen, in the long-term, renewable hydrogen is projected to be sourced by capturing otherwise curtailed solar and wind power and, through electrolysis, generate hydrogen. The natural gas distribution system is immediately available as a resource to store and distribute this "Power-to-Gas (P2G)" supply of renewable hydrogen. At some point, dedicated hydrogen pipelines will serve as the storage and distribution resource.

As the grid evolves, California will not reach a 100% renewable goal without a technology that provides clean, firm, renewable, and load-following power. While electric battery technology will be valuable, P2G and hydrogen storage technology will be the anchor that is required to capture the vast

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[9] Leal and Brouwer, ASME Journal of Fuel Cell Science and Technology, Vol 3, pp. 137- 143, 2006.

[10] Margalef, Brown, Brouwer, and Samuelsen, Journal of Power Sources, Vol 196, pp. 2055- 2060, 2011.

[11] *Air Quality and Greenhouse Gas Emissions Impact Assessment from Biomass and Biogas Derived Transportation Fuels and Electricity and Heat Generation, California Energy Commission*, CEC-500-2016-022, March, 2015.

majority of otherwise curtailed renewable resources for later use. Fuel cells are the one technology that has evolved to utilize renewable hydrogen and provide the clean, 24/7 load-following capability to manage and buffer the dynamics of solar and wind, with zero criteria pollutant and greenhouse gas emissions.

Respectfully submitted,

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