DOCKETED

Docket Number:	17-IEPR-07
Project Title:	Integrated Resource Planning
TN #:	217932
Document Title:	Comments of the National Fuel Cell Research Center, IEPR Integrated Resource Planning for Renewable Fuel Cell Applications
Description:	N/A
Filer:	System
Organization:	National Fuel Cell Research Center, UC Irvine
Submitter Role:	Public Agency
Submission Date:	6/7/2017 3:56:05 PM
Docketed Date:	6/7/2017

Comment Received From: Scott Samuelsen
Submitted On: 6/7/2017
Docket Number: 17-IEPR-07

Comments of the National Fuel Cell Research Center, IEPR Integrated Resource Planning for Renewable Fuel Cell Applications

Additional submitted attachment is included below.

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June 7, 2017

California Energy Commission
MS Dockets Office, MS-4
Re: Docket No. 17-IEPR-07
1516 Ninth Street
Sacramento, CA 95814-5512

Re: IEPR Integrated Resource Planning for Renewable Fuel Cell Applications

The National Fuel Cell Research Center (NFCRC) submits these comments on the Integrated Resource Planning Docket #17-IEPR-07 of the California Energy Commission's (CEC) Integrated Energy Policy Report (IEPR) to affirm and emphasize the importance of recognizing firm power and GHG-reducing fuel cells as critical to complement and manage the high penetration of intermittent solar and wind, cornerstones in achieving the California 40% GHG emissions reduction goal by 2030.

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, power-to-gas combined with renewable hydrogen storage and fuel cell technology will be required to capture the vast majority of otherwise curtailed renewable resources for later use. Fuel cell technologies are the only technologies that have evolved to utilize the renewable hydrogen and provide the clean, 24/7 load-following capability to manage and buffer the dynamics of intermittent solar and wind. This is especially the case for high renewable use that leads to massive and long duration (e.g., seasonal) demands for storage of intermittent renewable energy.

In addition to compelling environmental attributes, fuel cells have the highly dynamic dispatch capabilities needed to (1) manage the diurnal variation, constrained capacity factor, and intermittencies associated with solar and wind power generators, and (2) increase the maximum penetration of renewable resources that can be accommodated in the utility grid network.

Fuel cells are considered the cleanest, most efficient distributed energy resource for utility procurement and firm power. Power generation produced through natural gas combined cycle (NGCC) combustion turbine power plants today meets the majority of electricity demand in California, but with the emission of criteria pollutants (e.g., NOx) and efficiencies limited by heat engine constraints. When using natural gas, fuel cells reduce GHG,[1] generate virtually zero criteria pollutant emissions, and operate with high efficiencies. Fuel cells also operate in a virtual water balance. To illustrate, the use of a 400kW fuel cell system to generate combined heat and power for a building can save over one million gallons of water annually, compared to the water required to generate the same amount of

[1] *Final Report: SGIP 2014-2015 Impacts Evaluation Report.* Submitted by Itron to SoCalGas and the SGIP Working Group, September 29, 2016. http://www.cpuc.ca.gov/sgip/

electricity at a central power plant. When operated on renewable hydrogen, fuel cell systems produce dispatchable power with zero greenhouse gas and zero criteria pollutant emissions.

Grid Benefits of Fuel Cells

As the dynamic environment of the grid increases, the deployment of fuel cell systems will be required to directly complement the intermittent renewable power generation throughout the state, provide increasingly valuable ancillary services (e.g., ramping, capacity, voltage and frequency support) to the utility grid network, and improve the reliability and stability of the utility grid network's high use of renewable power generation. [2,3] These attributes of stationary fuel cell technology serve as a primary example of exportability, and rate structures are required to compensate this clean, load-following resource.

Fuel cells also operate on biogas with over 30% of the power generated by fuel cells in California today produced from biogas. When operated on biogas, fuel cells generate electricity and heat (and bio hydrogen if appropriately configured) with zero net carbon emissions. Fuel cells are also capable of operation on renewable hydrogen in response to the evolution of a supply 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.

Distributed Resource Planning allows for GHG-reducing fuel cells to be included in bidding for all utility-scale procurements. As part of Distributed Resource procurements, fuel cells can provide unique co-benefits. As yet another example of exportability, large-scale fuel cell systems are deployed today on the utility side of the meter to create grid support solutions where transmission is constrained or increased reliability is sought. Referred to as "Transmission Integrated Grid Energy Resource" or "TIGER" stations, these resources are providing clean, 24/7, load-following power generation to complement the increasing deployment of intermittent solar and wind resources and support grid reliability in locations where it is most needed – including in disadvantaged communities. Examples range from a 15MW system in Connecticut, to a 30MW system in Delaware, to a 59MW system in Seoul, Korea.

The ability of fuel cells to provide constant, high quality power in a primary or backup role has increasing importance due to the reliance on electronics by many essential industries that include banking, communication, and telecommuting. There are additional concerns that the vulnerability of an aging electrical grid in many locations could result in increasing susceptibility to outages. Because grid outages result in significant costs and other detriments, the ability of fuel cells to generate backup power independent of the grid or to operate as a building's primary source of power is particularly beneficial to consumers who must have constant availability of high quality power to maintain critical operations. Examples of such entities include data centers, banks, hospitals, grocery stores, and government agencies. Fuel cells have successfully demonstrated this ability during recent regional grid outages (e.g., September 2011 San Diego County) and major natural disasters (e.g., Superstorm Sandy

[2] Maton, Jean-Paul, Zhao, Li, and Brouwer, Jacob, *Dynamic modeling of compressed gas energy storage to complement renewable wind power intermittency*, International Journal of Hydrogen Energy, Volume 38, pp. 7867-7880, 2013.

[3] Shaffer, Brendan, Tarroja, Brian, Samuelsen, Scott, *Dispatch of fuel cells as Transmission Integrated Grid Energy Resources to support renewables and reduce emissions*, Applied Energy, Volume 148, 15 June 2015, Pages 178-186.

and Hurricane Irene) by sustaining power to essential telecommunication technologies, grocery stores, and storm shelters.[4]

The Distributed Generation (DG) model has the potential to introduce new sources of pollutant emissions into urban airsheds with large populations, thereby raising concerns for human health in areas of California that include the South Coast Air Basin (SoCAB), and San Joaquin Valley[5]. SoCAB currently suffers from poor air quality and faces major challenges in achieving clean air for the many citizens that live and work within its boundaries. This is particularly true for economically disadvantaged communities that are often disproportionately burdened by air pollution. Therefore, DG technologies such as fuel cells that can provide clean, efficient energy conversion for many different industries and applications can also provide a wide range of energy, environmental, health and economic benefits that have significant value to the State.

Emissions Mitigation

Fuel cells address simultaneously the mitigation of CO_2, criteria air pollutants, and short-lived climate pollutants – 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 enable 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. Of particular importance, with the supply of renewable hydrogen evolving in the future 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. In this mode, 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.

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.

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[4] Supplemental Report: *The Science of Fuel Cells; 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, April 31, 2016.

[5] Carreras-Sospedra, M., et al., *Central power generation versus distributed generation-An air quality assessment in the South Coast Air Basin of California*. Atmospheric Environment.

The Intersection of Stationary and Transportation Power Sources

Fuel cell use in transportation applications will enable the additional use of renewable hydrogen in zero emissions transportation applications. Fuel cell technology utilized 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 fuel cell technology in transport applications.

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,[6, 7] 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 transportation (including 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.[8]

100% Renewable Grid

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, power-to-gas and hydrogen storage technology will be the anchor that is required to capture the vast 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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[6] *Requirements at the Port of Long Beach.* MacKinnon, M and Samuelsen, S. Advanced Power and Energy Program, University of California Irvine, April 31, 2016.

[7] *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

[8] Ibid.