JOINT FUEL CELL PARTIES:
NATIONAL FUEL CELL RESEARCH CENTER; BLOOM ENERGY; DOOSAN FUEL CELL AMERICA; LG FUEL CELL SYSTEMS
Comments on Fuel Cell Net Energy Metering Program Greenhouse Gas Emission Standard
June 14, 2017
Request for Comments Issued June 1, 2017

The Joint Fuel Cell Parties (National Fuel Cell Research Center, Bloom Energy, Doosan Fuel Cell America, and LG Fuel Cell Systems, Inc.) submit these comments to the California Air Resources Board regarding the Fuel Cell Net Energy Metering Program Methodology for the Greenhouse Gas (GHG) Emission Standard.

I. Introduction

GHG-reducing fuel cells are a unique technology needed to complement and manage the high penetration of intermittent solar and wind, cornerstones for achieving the California 40% GHG emissions reduction goal by 2030.

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 California's statewide Integrated Resource Planning. [1]

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 be configured for the capture, concentration, and storage of the resulting CO_2. The 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 reduction of carbon emissions. This represents an immediate benefit that may be further expanded as the market for biogas and other renewable fuels (e.g., renewable hydrogen) evolves to make cost-effective and accessible renewable gas supplies widely available. Particularly important, as the renewable gas supply evolves, fuel cells are the only technology that will operate on renewable hydrogen with zero emissions, while at the same time enabling massive capture and storage of renewable power that would otherwise be curtailed. In this mode, the fuel cell will be a firm (24/7) 100% load-following renewable and zero emissions generator.

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

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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/General.aspx?id=7890

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 the exhaust heat to produce chilled water, thereby displacing traditional chlorofluorocarbons (CFC)-based systems and the associated leakage.

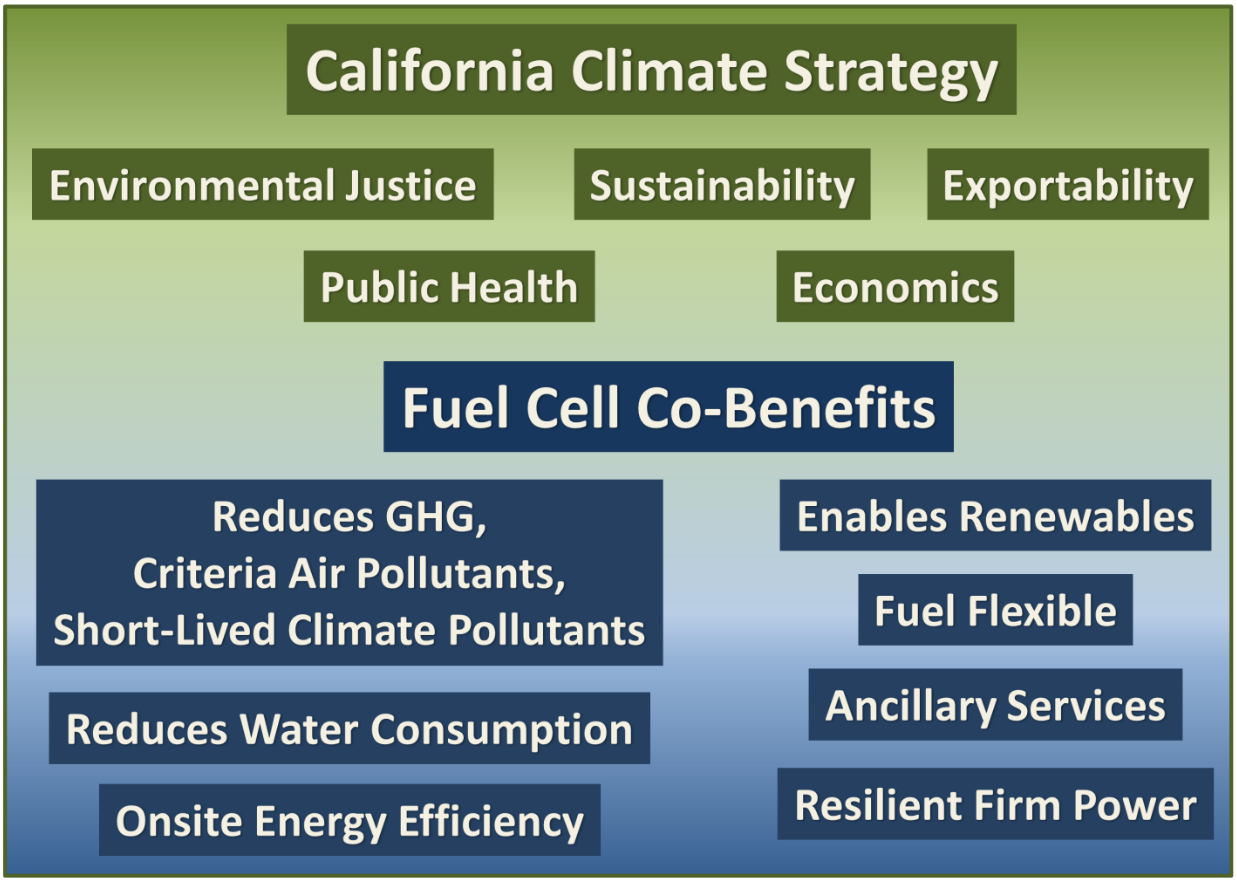

Figure 1: Climate Change Co-Benefits of Fuel Cells

Fuel cells have highly dynamic dispatch capabilities to (1) manage the diurnal and seasonal power demand variations, (2) handle intermittencies associated with solar and wind power generators, and (3) increase the maximum penetration of renewable resources that can be accommodated in the utility grid network. [2,3] These capabilities will result in maximum sustainability and additional GHG reductions through the integration of renewables with transportation electrification.

[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.

In addition to generating electrical power, stationary fuel cells have the capability to cogenerate a thermal product. This option, referred to as Combined Cooling, Heat, and Power (CCHP), is designed to capture and utilize the heat produced by the fuel cell for the provision of cooling, heat, hot water, or steam. It results in overall fuel cell system efficiencies (electrical power generation and use of the captured thermal energy) ranging from 55% to 80%[4] and, with a judicious design, exceeding 90%.[5] This attribute also displaces the fuel and emissions that would otherwise be associated with (1) boilers when using the thermal energy as heat, and (2) the displaced electricity to drive chillers when using the thermal energy for cooling. The resultant effect is to dramatically reduce CO_2 emissions, criteria pollutant emissions, and the demand on fuel reserves. In contrast to combustion heat engines, fuel cells are unique in providing high fuel-to-electricity efficiency and high quality (i.e., high temperature) heat, as well as producing virtually zero emission of criteria pollutants.[6]

Stationary fuel cells can be used to improve the quality of power provision and infrastructure where it is truly needed, while also contributing to cleaner air and improved health of citizens. In fact, fuel cells are suitable for citing near or even inside buildings, due to virtually zero pollutant emissions, an acoustically benign attribute, and the avoidance of the challenges related to permitting and zoning.

II. Comments

A. Key Considerations

1. <u>Marginal energy resource mix and displacement assumptions</u>

We strongly encourage the California Air Resources Board (CARB) to adopt the most technically accurate methodology for estimating the marginal energy resource mix that would be displaced by fuel cell systems operating under the net energy metering tariff.

The resource mix on the margin, i.e. the resource mix that an electricity provider would increase or decrease in response to energy demand, is the appropriate reference as the resource mix that the fuel cell would displace. Long-term and must take contracts (non-marginal resources) are not altered based upon the use of fuel cells on the customer's side of the meter.

[4] Darrow, K., et al., Catalog of CHP Technologies 2015: Available at http://www.epa.gov/sites/production/files/2015-07/documents/catalog_of_chp_technologies.pdf (Accessed January 12, 2015).

[5] Ellis, M.W., M.R. Von Spakovsky, and D.J. Nelson, *Fuel cell systems: efficient, flexible energy conversion for the 21st century.* Proceedings of the IEEE, 2001. 89(12): p. 1808-1818.

[6] *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.

Significant research and development related to the historical, current and future marginal energy resource mix in California has already been accomplished and is already in widespread use in support of California policy goals. We expressly encourage the use of statewide, complete annual hourly data (8760 hours) for characterizing the marginal energy resource mix for use in determining the GHG emissions requirements for fuel cell systems operating under the net energy metering tariff.

Several examples of technically accurate methodologies for marginal energy resource mix assessment are currently available for CARB to use directly or to pattern their analyses after. One example is the publicly available avoided cost calculator (ACC) developed by Energy + Environment Economics (E3).[7] This tool is used for assessing the impacts of utility energy efficiency measures (which are identical in effects on the grid to behind-the-meter power generation from a fuel cell). This ACC tool has been updated in 2016 with thorough documentation of the methodology that is publicly available for scrutiny and use.[8] A second example that accurately determined the hourly marginal resource mix for an entire year is the analysis accomplished by Itron in their 2014-2015 Self-Generation Incentive Program (SGIP) Impacts Evaluation.[9] Another example is that of WattTime, a nonprofit organization that combines real-time data from grid operators and the U.S. EPA to determine accurate marginal grid emissions that reflect the dynamics of the grid.[10]

All of these examples use data from the California Independent System Operator (CAISO), and other balancing authorities that serve California, to accurately calculate the statewide hourly marginal resource mix for an entire year (with various assumptions). These data should be available to CARB in this year and all subsequent years to enable a regular update of the GHG emissions standard (e.g., every three years as required by statute).

2. **Role of renewable resources in the resource mix**

We strongly encourage CARB to use grid operations data and analyses as described above to accurately account for the hourly contribution of renewable power generators to the marginal resource mix. All of the methodologies introduced above include thorough and accurate consideration of the renewable power contribution to the marginal resource mix.

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[7] California Public Utilities Commission, Energy + Environment Economics, Energy Efficiency Calculator, available on-line at: https://www.ethree.com/public_proceedings/distributed-energy-resources-der-avoided-cost-proceedings/

[8] Brian Horii, et al., Energy + Environment Economics, Avoided Costs 2016 Interim Update, available on-line at: http://www.cpuc.ca.gov/General.aspx?id=10710, August 1, 2016.

[9] 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/

[10] http://watttime.org/

We discourage the use of an arbitrary renewable power generation factor, or a factor that scales with the renewable portfolio standard or annual renewable energy percentage, because none of these factors take into account the dynamics of renewable power generation on the grid or accurately reflect the contribution of these resources to power generation on the margin. Rather, we encourage the hourly marginal generation resource mix approaches outlined above together with regularly updated data from balancing authorities to accurately account for renewable power marginal contributions and dynamics on the grid.

Distributed generation and fuel cell systems do not prevent the building of renewable power plants. To the contrary, rather than displacing renewable resources, fuel cells are clean distributed generators that are required to facilitate the deployment of renewables. Based on grid simulation studies at UCI's Advanced Power and Energy Program, fueled, controllable and dynamic power generation such as that produced by fuel cells is required to achieve high levels of renewables.[11,12,13]

Fuel cell technology, with unprecedented low criteria pollutant emissions that enable installation even in the most restrictive of air quality permitting regions, also provides firm power generation to areas of significant grid congestion, preventing the need for additional centralized generation capacity and transmission equipment. These installations offset traditional grid infrastructure and support the installation of additional renewable power systems.

In addition to the direct displacement of central power emissions, firm clean power generation can provide the additional benefit of locally complementing the diurnal variation and intermittent generation profile of renewable power systems. Fuel cells can be used to stabilize this profile, and displace existing baseload, load-following, and peaking power plants that would otherwise be required to address the diurnal and intermittent characteristics associated with renewable power. If distributed, firm power generation resources are not installed, the grid will be forced to curtail renewable power during periods of low power demand or high renewable generation due to grid reliability concerns.

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[11] *Dispatch of Fuel Cells as Transmission Integrated Grid Energy Resources to Support Renewables and Reduce Emissions* (2015). Applied Energy, Vol. 148, pp. 178-186 (Brendan Shaffer, Brian Tarroja, and Scott Samuelsen).

[12] *Exploration of the Integration of Renewable Resources into California's Electric Systems Using the Holistic Grid Resource Integration and Deployment (HiGRID) Tool* (2013). Energy, Vol. 50, pp. 353-363 (Josh Eichman, Fabian Mueller, Brian Tarroja, Lori Schell, and Scott Samuelsen).

[13] *Solar Power Variability and Spatial Diversification: Implications from an Electric-Grid Load Balancing Perspective* (2013). International Journal of Energy Research, pp. Vol. 37, No. 9, pp. 1002–1016 (Brian Tarroja, Fabian Mueller, and Scott Samuelsen).

3. **Line losses**
   We recommend that line losses be included in the calculation of the GHG standard. It is technically accurate to use line losses in the calculations since all of the marginal resources that fuel cell systems would displace are subject to line losses that are required to deliver the power to the customer. The statewide loss factor should be a load weighted average of all utility service area loss factors based upon the most up to date California Energy Demand Adopted Forecast from the California Energy Commission.

4. **Grid response to small load changes**
   We strongly encourage the use of marginal resource mix calculations based upon data for annual hourly performance of the California grid, as described above. If this approach is adopted, then the grid response to small load changes will be accurately assessed. We discourage the use of grid average emissions or any other factor that aggregates the emissions of resources that are not affected by small load changes (e.g., must-take or non-load following resources) with those that are actually on the margin. Because data on grid operations at hourly intervals is available, we also discourage using less granular data (e.g., monthly) for establishing the GHG Standard.

5. **Interpretation of "reduces greenhouse gas emissions compared to the electrical grid resources"[14]**
   We encourage CARB to set a standard that clearly demonstrates that net energy metered fuel cell systems will reduce emissions compared to the marginal mix of grid resources that would otherwise have been dispatched. We recommend that the GHG standard be set on point lower than the exact level of emissions which the grid marginal resources would have produced, rather than at an arbitrarily lower number or arbitrarily decided percentage reduction.

B. Recommended Test Procedures

The inclusion of relevant greenhouse gases in the GHG standard methodology in addition to carbon is relevant and appropriate. We support the inclusion of N_2O and methane in the GHG standard, as the statute directs the Board to establish a GHG reduction (i.e. CO_2e) standard rather than a CO_2 reduction standard. We urge the Board to ensure that whatever testing is required for these additional GHGs are appropriate for use with stationary fuel cells. The methods presented in Slide 7 of the Fuel Cell Net Energy Metering GHG Emission Standards Workshop presentation were neither designed nor appropriate for measuring emissions from stationary power generation systems. Emissions of N_2O and methane from

[14] PU Code 2827.10(b)(2) The greenhouse gas emissions reduction standards shall ensure that each fuel cell electrical generation resource, for purposes of clause (iii) of subparagraph (A) of paragraph (3) of subdivision (a), reduces greenhouse gas emissions compared to the electrical grid resources, including renewable resources, that the fuel cell electrical generation resource displaces, accounting for both procurement and operation of the electrical grid.

fuel cell systems are so low that they are typically below detection limits of standard testing. While these gases contribute negligibly to total GHG emissions from fuel cells, we understand the need for a direct comparison of emissions from fuel cells to that of marginal grid resources and will work with Staff to ensure that testing requirements are appropriate and accurate.

We strongly encourage type certification of fuel cell systems in a manner that is similar to the CARB distributed generation (DG) certification program. Individual on-site measurement of fuel cell system performance would be costly because the systems are small and distributed. Testing on a site by site basis would not add value.

III. Conclusion

GHG-reducing fuel cells are considered the cleanest, most efficient distributed energy resource for firm, controllable, and dispatchable power. When operating on natural gas, fuel cells reduce GHG compared to generation from the current grid and generate virtually zero criteria pollutant emissions. When using renewable bio fuels, they are carbon neutral. With renewable hydrogen as a fuel source, fuel cells emit zero GHGs. In addition, fuel cells operate in a virtual water balance, with no significant consumption of water in normal operations.

As the grid evolves, California will not reach high penetrations of renewables without a technology that provides clean, firm, renewable, and load-following power.

Establishing an accurate GHG standard for the net energy metering of fuel cell systems is very important to the near-term and long-term market for fuel cell systems. The GHG standard will assure and confirm the GHG reducing features of fuel systems compared to the mix of all other technologies that could have otherwise been used to provide the energy services (power, heating, cooling) that clean distributed fuel cell systems provide. The GHG standard can also facilitate the evolution of fuel cell installations over time to make them increasingly GHG emissions free, as the standard is updated every 3 years in an accurate manner. The most accurate way to establish such a GHG emissions standard is to use and build upon the significant previous scientific research and development that has already occurred to determine the marginal resource mix. The methodology used by CARB to establish the GHG emissions standard should assess the annual hourly (all 8760 hours of the year) marginal resource mix based upon grid operations data in the appropriate year, as described above.

The Joint Fuel Cell Parties appreciate the opportunity to comment on the development of a Fuel Cell Net Metering GHG Standard through the above recommendations to facilitate this evolution.

Sincerely,

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