NATIONAL FUEL CELL RESEARCH CENTER
Comments on November 7 Public Workshop on the 2030 Target Scoping Plan Update: GHG Policy Scenarios, Natural & Working Lands, and Public Health Analysis

The National Fuel Cell Research Center (NFCRC) submits these comments to affirm and emphasize the importance of recognizing fuel cells as a major and critical resource in the California Air Resources Board's (CARB) strategy for a low-carbon future. The forthcoming update to the Climate Change Scoping Plan should include GHG reducing natural gas fuel cells, as a unique 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.

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 the Scoping Plan. For CO_2, high fuel-to-electrical efficiency significantly reduces the carbon emitted per MW-hr. The unusually high operating temperatures of fuel cells enable the cogeneration of heat, steam, or chilled water, thereby displacing conventional, carbon emitting sources (e.g., grid electricity, natural gas boilers, and natural gas furnaces). Fuel cells operate today on biogas, further contributing to the management of carbon. Particularly important, as supply evolves, fuel cells will operate in the future on renewable hydrogen as the principal strategy to capture and store energy that would otherwise be curtailed. In this mode, the fuel cell will be a firm (24/7) 100% load-following renewable generator.

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

For short-lived climate pollutants, fuel cells are an ideal technology to mitigate the emissions. Fuel cells, for example, generate electricity and heat from methane sources otherwise vulnerable to seepage such as landfills, water resource recovery facilities, and dairies. In addition, fuel cells have the capability to be configured for the capture, concentration and storage of the resulting CO_2. For chlorofluorocarbons (CFCs), fuel cells are today capturing and using the exhaust heat to produce chilled water, thereby displacing traditional CFC-based systems and the associated leakage.

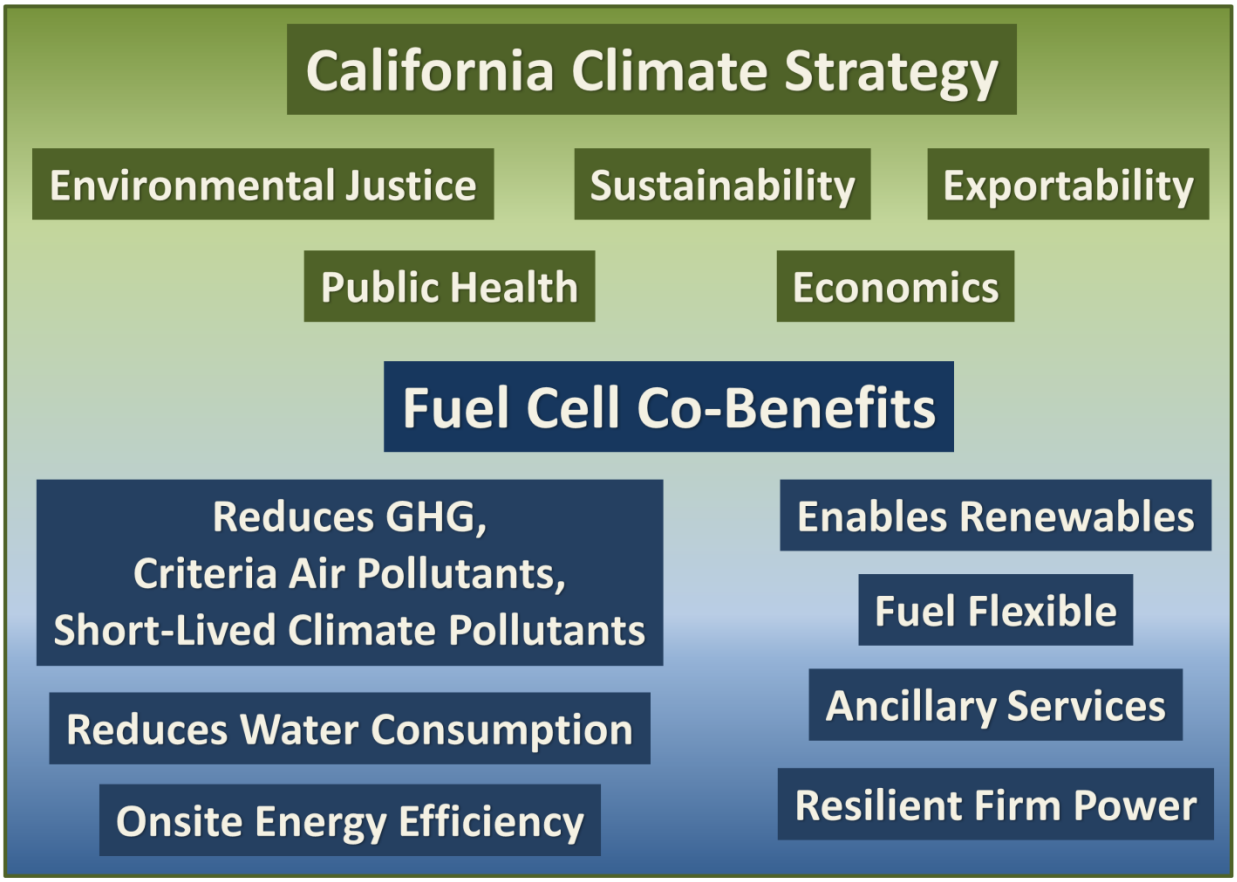

Figure 1: Climate Change Co-Benefits of Fuel Cells

Recommendations

The NFCRC presents the following recommendations to underwrite the inclusion of fuel cell systems in the 2016 update to the Climate Change Scoping Plan.

1. **Fuel cells are considered the cleanest, most efficient distributed energy resource for utility procurement.** ***(Energy Sector – Electricity and Natural Gas, Water Sector – Electricity and Technology Natural and Working Lands Sector – Land Use Planning)***

   Power generation produced through natural gas combined cycle (NGCC) gas turbine power plants today meets the majority of electricity demand, but with the concomitant emission of criteria pollutants (e.g., NOx) and efficiencies limited by heat engine constraints. When using natural gas, fuel cells reduce GHG compared to generation from the current grid and generate virtually zero criteria pollutant emissions. Fuel cells operate in a virtual water balance, with no significant consumption of water in normal operations. To illustrate, the use of a 400kW fuel cell system to generate combined heat and power at a building can save over one million gallons of water annually compared to the water required to generate the same amount of electricity at a central power plant.

   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 emitted. Fuel cells are capable of

operation as well on renewable hydrogen in response to the evolution of a supply associated with the generation, storage, and utilization of wind energy 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.

Distributed Resource Planning allows for fuel cells to bid in all utility-scale procurements. As such, these procurements should be open to include fuel cells. 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.

2. Clean, firm power fuel cells will provide ancillary services to the utility grid network (e.g., ramping, capacity, voltage and frequency support) to enable high renewable power use. ***(Energy Sector – Demand Response, Renewable Energy, Electricity)***

Fuel cell systems should be installed for the express purpose of supporting capacity needs throughout the utility grid network, and rate structures developed to compensate this clean, load-following resource for providing increasingly valuable ancillary services (e.g., ramping, capacity, voltage and frequency support) to the utility grid network. The express purpose for installing and operating fuel cell systems in a highly dynamic environment is to directly complement intermittent renewable power generation throughout the state, and improve the reliability and stability of the utility grid network's high use of renewable power generation.[1,2] These attributes of stationary fuel cell technology serve as another primary example of exportability.

Fuel cells have highly dynamic dispatch capabilities 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. These capabilities will result in maximum sustainability and additional GHG reductions through the integration of renewables.

3. Fuel cells are an important component of the program to bring new low emissions technology to ports. ***(Transportation Sector – Sustainable Freight)***

The ports of California face both challenges and opportunities in managing and meeting future energy and public health requirements. The different types of fuel cell technology types that are emerging can facilitate meeting future energy requirements and contribute co-benefits to port

[1] 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.

[2] 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.

energy and environmental goals,[3, 4] including 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 a system and 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, and virtually net zero water consumption.[5]

As an example, the Port of Long Beach (POLB) is located in the South Coast Air Basin of southern California which experiences high levels of health damaging air pollution (also termed air quality). The deployment of stationary fuel cell systems provides a means of distributed self-generation for the POLB without the addition of emissions to operations.[6] This is a key co-benefit of fuel cells as other methods of combustion-driven self-generation (e.g., natural gas turbines, 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 minimizing criteria pollutant emissions. The use of fuel cells at the POLB will reduce local criteria pollutant emissions and 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[7] and the Green Port Policy.[8, 9]

4. Combined heat and power programs recognize fuel cells as the cleanest, most efficient method to produce on-site heat and power. *(Energy Sector – CHP, Green Buildings Sector – Net Zero Carbon Buildings)*

In addition to generating electrical power, stationary fuel cells have the option to cogenerate a thermal product. The strategy, referred to as Combined Cooling, Heat, and Power (CCHP), is to capture and utilize the heat produced by the fuel cell for the provision of cooling, heat, hot water, or steam. This results in overall fuel cell system efficiencies (electrical power generation and use of the captured thermal energy) ranging from 55% to 80%[10] and, with a judicious design, exceeding 90%.[11]

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[3] *Requirements at the Port of Long Beach.* MacKinnon, M and Samuelsen, S. Advanced Power and Energy Program, University of California Irvine, April 31, 2016.

[4] 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

[5] *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.

[6] Ibid.

[7] http://www.cleanairactionplan.org/

[8] http://www.polb.com/environment/green_port_policy.asp

[9] *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.

[10] 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).

[11] 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.

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.[12]

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, being acoustically benign, and the avoidance of the challenges related to permitting and zoning.

5. Replacement of diesel backup generators with fuel cell systems with critical load islanding capabilities. *(Short-lived Climate Pollutants, Energy Sector – Industry, Agriculture Sector – Water and Fuel Use, Land Use, Green Buildings Sector – Net Zero Carbon Buildings)*

Fuel cells can significantly reduce GHG, short-lived climate pollutants and criteria air pollutant emissions, and also increase the resiliency and reliability of the electricity supply to consumers. The ability of fuel cells to provide constant, high quality power in a primary or backup role has increasing importance because of the reliance on electronics for many essential industries such as 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 cause significant costs and other detriments, the ability of fuel cells to generate backup power independent of the grid to grid-connected buildings (or to operate as a building's primary source of power) is beneficial – particularly 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 through several recent natural disasters including providing power to essential telecommunication technologies, grocery stores, and storm shelters during Super-storm Sandy and Hurricane Irene.[13]

The Distributed Generation (DG) model also has the potential to introduce new sources of pollutant emissions into urban airsheds with large populations and thereby raising concerns for human health – including in the South Coast Air Basin (SoCAB), and San Joaquin Valley of California[14]. 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 produce a wide range of energy, environmental, and economic benefits that have significant value to the State.

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[12] *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.

[13] Ibid.

[14] 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.

Beyond the existing waiver of permitting requirements for fuel cell systems, the California Air Districts should incent the replacement of diesel backup generators with fuel cells. Recognizing the superior co-benefits of fuel cells, a program can be created to both limit new permitting of diesel generators and to provide an option to use fuel cell systems for onsite and backup power.

6. **Biogas sources and infrastructure should be researched and developed throughout the state.** ***(Energy Sector - Renewable Energy, Transportation Sector – Fuels, Waste Management Sector – Methane Capture)***

   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[15] 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.

7. **Fuel cells should be integrated into Water Resource Recovery Facilities for both onsite heat and power generation and the production of renewable hydrogen.** ***(Water – Electricity and Technology, Transportation – Fuels, Short-lived Climate Pollutants)***

   Fuel cells at water resource recovery facilities are an ideal nexus of the energy, water and waste sectors. Stationary fuel cells, fueled by biogas at these facilities, produce 24/7 renewable electricity that is used to power the facility, and heat that is directly used to heat the digester, resulting in a sustainable, zero emission system. The provision of a capability to tri-generate and dispense hydrogen has been successfully demonstrated at the Orange County Sanitation District. In addition to virtually zero emission of criteria pollutants, regardless of fuel source, fuel cell systems consume virtually net-zero water in the production of energy.

   The use of fuel cells at water resource recovery facilities additionally sets a precedent for the expansion of fuel cells powered by anaerobic digester gas in other industries, such as wineries, breweries, confined animal feeding operations (CAFOs), food processing facilities[16], and other sites processing organic waste through anaerobic digestion.

8. **Fuel cells must receive interconnection in all utility jurisdictions given their superior co-benefits.** ***(Energy Sector – Electricity and Natural Gas, Water Sector – Electricity and Technology Natural and Working Lands Sector – Land Use Planning)***

   Fuel cell systems continue to experience barriers to adoption in the interconnection process. In order to realize the significant co-benefits of GHG and criteria air pollutant reduction, streamlined processes for interconnection in utility territories statewide should be developed.

[15] *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.
[16] *Fuel Cells at Wastewater Treatment Plants,* Fuel Cell and Hydrogen Energy Association. www.fchea.org

The First Update to the Scoping Plan Update calls for:

> A CPUC proceeding to continue to streamline state jurisdictional interconnection processes to create a ministerial low-cost interconnection process for distributed generation completed by the end of 2015. The CEC to explore similar streamlined processes for interconnecting distributed generation in publicly owned utility systems. The CPUC and CEC consult as appropriate with the CAISO as part of these proceedings.[17]

This recommendation to streamline the interconnection process for distributed generation remains relevant and continues to require interagency cooperation.

Summary

The NFCRC works with Bloom Energy, Doosan Fuel Cell America, Fuel Cell Energy, GE-Fuel Cells, and LG Fuel Cell Systems, Inc. These organizations request the inclusion of fuel cells in the Climate Change Scoping Plan through the following recommendations:

1. **Fuel cells are considered the cleanest, most efficient distributed energy resource for utility procurement.**
2. **Clean, firm power fuel cells will provide ancillary services to the utility grid network (e.g., ramping, capacity, voltage and frequency support) to enable high renewable power use.**
3. **Fuel cells are an important component of the program to bring new low emissions technology to ports.**
4. **Combined heat and power programs recognize fuel cells as the cleanest, most efficient method to produce on-site heat and power.**
5. **Replace diesel backup generators with fuel cell systems with critical load islanding capabilities.**
6. **Biogas sources and infrastructure will be researched and developed throughout the state.**
7. **Fuel cells will be integrated into Water Resource Recovery Facilities for both onsite heat and power generation and the production of renewable hydrogen.**
8. **Fuel cells shall receive interconnection in all utility jurisdictions given their superior co-benefits.**

Sincerely,

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[17] *First Update to the Climate Change Scoping Plan, Building on the Framework, Pursuant to AB 32 The California Global Warming Solutions Act of 2006*, May 2014. California Environmental Protection Agency, Air Resources Board.