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Additional submitted attachment is included below.

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California Energy Commission
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Re: Docket No. 19-IEPR-06
1516 Ninth Street
Sacramento, CA 95814-5512

Subject: 2019 IEPR Joint Agency Workshop on Energy Efficiency and Building Decarbonization: Docket Number 19-IEPR-06

The National Fuel Cell Research Center (NFCRC) submits these comments on the August 27, 2019 California Energy Commission (CEC), California Air Resources Board (CARB), California Independent System Operator (CAISO) and California Public Utilities Commission (CPUC) Joint Agency Workshop on Building Decarbonization.

I. Introduction

The NFCRC facilitates and accelerates the development and deployment of fuel cell technology and fuel cell systems; promotes strategic alliances to address the market challenges associated with the installation and integration of fuel cell systems; and educates and develops resources for the various stakeholders in the fuel cell community. A primary mission of the NFCRC is to enable the improvement of air quality and reduction of greenhouse gas emissions through increased use of distributed generation and clean energy sources.

The NFCRC was established at the University of California, Irvine by the U.S. Department of Energy (DOE) and the CEC with the goal of both developing and transitioning to a form of power generation that is both energy efficient and environmentally sensitive. The DOE has recognized the significance of the NFCRC efforts in bringing government agencies, business and academia together to develop effective public-private alliances -- in the case of the NFCRC, in order to develop advanced sources of power generation, transportation and fuels.

II. Comments on the August 27 Workshop

A. Decarbonization is Not Synonymous with Electrification

The draft staff report for the 2019 energy efficiency action plan and building decarbonization from the CEC proposes to focus on electrification as the main (or only) pathway to achieve building decarbonization with the following statement:

"Renewable gas can be a part of the solution to reducing GHG emissions from buildings, but its role is likely constrained by availability, cost, and ongoing methane leakage concerns. Therefore, future building decarbonization efforts will focus on electrification of new and existing buildings." (page 6)

Technology neutrality yields the most cost-effective solution for each ratepayer and leads to maximum GHG reduction while also maintaining customer choice. Developers and communities need the flexibility to decide if they want all-electric buildings. They should be free to determine for themselves if all electric new construction or all electric conversion of existing buildings together with the commensurate electric infrastructure is preferred to the decarbonization of both electric and gas systems. They should be able to determine for themselves from cost, functionality, and nearby availability of infrastructure reasons which particular buildings and communities should completely electrify and decarbonize electric generation and which should decarbonize both gas and electric delivery to the buildings. Electrification should not be a statewide mandate because communities have different needs, different vintages of gas and electric infrastructure, different access to each system, different distances to existing infrastructures, and different end-use requirements that may require decarbonization of both the gas and electric grids.

A technology neutral approach is critical because California needs multiple approaches to most efficiently and effectively achieve the goal of decarbonizing buildings. For example, current research at the University of California, Irvine regarding the effectiveness of electric residential heating and cooling from heat pumps has resulted in initial findings that electric heat pumps may increase GHG emissions to the extent that heating demand is out of sync with renewable electricity production on both a diurnal and seasonal basis. This is generally the case because the primary demand for heating is at night and during the winter. The result is that heating is mostly used at night – when renewable solar is not available – and the increased nightly heating demand creates increased GHG from reliance on dirtier, less efficient and higher GHG emitting generators.

Similarly, there are seasonal challenges with only relying on one technology to provide electricity and heat; the preponderance of California's heating is required in winter when significantly less solar is available. Finally, there will be local transmission and distribution constraints, resiliency reductions associated with reliance upon one system for delivering energy, and higher costs associated with decarbonization in some cases if flexibility is not retained in the program.

<u>The CEC and the CPUC should not consider mandating building electrification as the only option to achieve zero carbon buildings in the IEPR. The emissions reduction potential associated with cooling equipment in various building types[1] is already being realized today by using fuel cell systems.</u>

Electrification or "fuel switching" from natural gas to electricity (as some presenters at the workshop called this concept) does not necessarily lead to lower greenhouse gas emissions. For example, the electrification of space and water heating with current average California electricity generation reduces less GHG emissions than a stationary fuel cell, which produces combined heat and power for the same amount of heating and electricity, even when the fuel cell uses natural gas as fuel. If the fuel cell uses some or all renewable gas, then the GHG emissions of the combined heat and power fuel cell are dramatically lower than those associated with electrification until and unless the utility grid network becomes 100% GHG emissions free.

Heat is demanded mostly at night and in the winter when the grid GHG emissions are higher (due to lower solar availability at these times). The dynamics of heat demand thus make the marginal GHG emissions profile of combined heat and power fuel cell systems even more GHG reducing compared to electrification.

The combined cooling, heating and power (CCHP) capability of stationary fuel cells to capture and utilize heat produced by the fuel cell for the provision of cooling, heating, hot water, or steam results in overall fuel cell system efficiencies (electrical power generation and use of the captured thermal energy) ranging from 55% to 80%[2] and, with a superior

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[1] Draft 2018 IEPR Update Volume II, at 33.
[2] Darrow, K., et al., Catalog of CHP Technologies 2015: Available at: https://www.epa.gov/chp/catalog-chp-technologies (Accessed January 12, 2015).

design and well-matched loads, exceeding 90%.[3] 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 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.[4] This clean electricity can also power heat pumps for further reductions in GHG emissions associated with building heating and cooling.

B. All of the Decarbonization Pathways Should Also Reduce Criteria Pollutant Emissions and Resulting Air Quality Impacts.

All policies for decarbonization of buildings should also reduce criteria pollutant emissions associated with the provision of all energy services to those same buildings. Electrification does eliminate local emissions associated with combustion to provide heat at the building, but does not eliminate the criteria pollutant emissions associated with grid electricity combustion. Today, about 65% of grid electricity involves combustion criteria pollutant emissions on average, and much more than 65% of electricity generation at night and in the winter involves combustion criteria pollutant emissions. In addition, all combustion backup generators produce criteria pollutants that lead to air quality problems and corresponding heath and quality of life impacts.

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[3] 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): at 1808- 1818.
[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.

Due to their high efficiency, non-combustion fuel cell systems are already reducing both GHG and criteria pollutant emissions associated with cooling and heating equipment in various building types today. In addition to electricity generation, the ability of stationary fuel cells to capture and utilize heat to provide cooling, heating, hot water, or steam results in very high overall fuel cell system efficiencies and leads to immediate reduction in local combustion generated criteria pollutant emissions that would otherwise be associated with the heating demand. In addition, the zero to near-zero criteria pollutant emissions of stationary fuel cell systems are also much lower than average grid criteria pollutant emissions leading to improved regional air quality compared to CA grid electricity. Thus, both all-electric and combined heat and power fuel cell systems reduce both criteria air pollutant emissions and GHG emissions.

Significant reductions in GHG emissions are achieved with fuel cell systems through:

1. Availability and high capacity factor of generation exceeding 95%;
2. Built-in, always-on resiliency (eliminating the need for back-up power),
3. Elimination of GHG emissions from fuel cell systems operating on 100% renewable fuel leading to dramatic overall GHG emissions reductions. (Note that the most significant previous GHG and criteria air pollutant reductions were achieved in the SGIP primarily from systems operating on natural gas).

Finally, fuel cells generate this clean electricity with no combustion and thus virtually no air quality reducing criteria air pollutants that harm human health. And when operating on renewable fuels, fuel cell systems produce completely decarbonized electricity, heating and cooling. **Overall, fuel cells are essential to decarbonizing buildings for key sectors of California's economy that also require always-on power.**

C. Resiliency Should Be a Core Facet of Building Decarbonization

Resiliency and reliability should be simultaneously achieved by introducing new technologies for building decarbonization. Decarbonization and resiliency are not and should not be considered mutually exclusive, and it is most cost-effective to address resiliency where possible while decarbonizing by creating building- and community-level distributed generation (with solar, fuel cells, batteries and other microgrid technologies) that includes backup power. The 2019 IEPR Update Scoping Order calls for continued state and stakeholder actions "to address major climate risks to the state's communities and energy system, recognizing differing vulnerabilities to the natural gas and electricity sectors" and "flexible and adaptive strategies to increase the state's resilience to multiple stressors from climate change on the energy system, with particular attention to vulnerable populations." [5]

The impacts of climate change are significantly pronounced in the electric utility sector. Public agencies, residents, and businesses must now dedicate vast resources to repairing damage from, and safeguarding against, climate catastrophes. To provide just one example, the California Energy Commission estimates that over the past 16 years, California's wildfires cost electrical utilities over $700 million to repair damaged transmission and distribution lines.[6] This total does not account for the cost to fight the wildfires, costs to businesses and consumers during outages, increased insurance premiums, damage to other public infrastructure, nor the incalculable loss of life. Given this "new normal," we encourage all building decarbonization efforts also consider and improve resiliency in the electrical sector, including the ability to withstand interruptions as well as quickly recover from outages of any kind.

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[5] *2019 Draft Scoping Order for the 2019 Integrated Energy Policy Report*, California Energy Commission, February 14, 2019 at 4.

[6] *http://www.climateassessment.ca.gov/techreports/docs/20180827-Energy_CCCA4-CEC-2018-002.pdf*

Fuel cell systems used in microgrids that may also contain solar power and battery energy storage, are uniquely designed to address these resiliency challenges. In addition to the benefits enumerated above, this innovative, non-combustion technology addresses multiple resiliency needs:

- Continuous power in the event of a grid outage or de-energization event;
- Baseload power in communities with constrained transmission, including disadvantaged communities or rural locations;
- Long-duration (longer than 24 hours) generation for emergency service centers, telecommunications and critical services such as hospitals, gas stations, and grocery stores. Indeed, the City of Hartford installed a fuel cell-powered microgrid to provide continuous power to these facilities that are co-located on the same block[7];
- By natively producing DC power, fuel cells are able to efficiently charge electric vehicles, buses, and other machinery during a grid outage and do so while minimizing the efficiency losses that occur when converting to AC power;
- Underground fuel lines eliminate the vulnerability to weather and risk of sparks from traditional poles and wires infrastructure;
- Modular design allows the system to continue operating even while individual components are being repaired or replaced;
- Time to build, uptime, and recovery time are all faster than the electric utility grid network can achieve;

[7] https://microgridknowledge.com/microgrid-and-fuel-cell-hartford/

- Leading power density: Fuel cells produce the largest quantity of zero emissions electricity in proportion to their equipment footprint compared to any technology currently on the market.

Furthermore, fuel cells can be, but do not need to be, connected to a storage device to provide these resiliency benefits. When paired with storage, wind, solar, demand response, or other technologies, fuel cell systems can serve as the backbone for microgrids that integrate numerous distributed energy resources and controls. Microgrids that use fuel cell systems as baseload power are able to immediately disconnect from the grid and island (operate autonomously) from the larger grid when circumstances demand (e.g., grid outage). The fuel cell installation innately operates as an energy management system, with critical loads for backup power already identified and immediately followed in the case of an outage. A fuel cell system can smoothly transition from the grid to fully power the load during a grid outage, without interruption to the end user, and to seamlessly re-connect to the grid when its power is restored.

Additionally, fuel cells displace traditional emergency backup generators that emit criteria air pollutants and GHG, including diesel generators. This feature is especially critical given that the majority of California currently suffers from poor air quality and faces major challenges in achieving clean air for the many citizens that live and work within these areas, including in economically disadvantaged communities that are often disproportionately burdened by air pollution. By providing always-on zero criteria pollutant emission power, fuel cells can increase adoption of intermittent renewable wind and solar resources throughout the state.

These benefits have directly translated into resilient performance in real-world disaster and grid interruption events. During the four storms that buffeted the East Coast from March 2-22 in 2018, millions of customers lost power, including those served by the electric grid in the vicinity of nine fuel cell microgrid sites. Despite the combined 26 electric utility outages, all nine fuel cell microgrids maintained power throughout these events. Other fuel cell systems in the Northeast powered critical communications and emergency shelters in the aftermath of these storms. Fuel cells also supplied critical load power to a healthcare facility during triple-digit temperature heat waves that triggered outages for 57,000 customers in Southern California in 2018. Additionally, fuel cells withstood the 2019 Ridgecrest earthquakes, the Sonoma fires in 2018, the 6.0 magnitude Napa earthquake in 2014, and even when a bulldozer was accidently dropped upon them at a customer site in 2016. Whether natural or human-caused, fuel cells have a critical role in providing valuable resiliency to all Californians.

The building decarbonization discussion is an excellent venue to identify cost-effective resiliency strategies, such as backup power options that displace polluting diesel generators. Additionally, it is important that the IEPR value and ensure the ability of technologies to reliably island for long durations while decreasing both GHG and criteria air pollutant emissions. Microgrids that use fuel cell systems as baseload power generators are able to immediately disconnect from the utility grid network and island (operate autonomously from the larger grid) when circumstances demand (e.g., grid outage), for days or weeks as required. Stand-alone fuel cell systems as distributed energy resources (DER) can also create resiliency outside of a microgrid and provide continuous clean power in addition to islanding connection to critical loads onsite.

Many of California's healthcare providers and other vital industries—e.g., data centers, advanced manufacturing—require this type of 24-7-365 energy delivery. Momentary losses of electricity to these commercial and industrial facilities are immensely damaging, potentially impacting health and well-being of citizens and costing thousands-of-dollars per each minute that critical loads are dropped, jeopardizing both the innovation and productivity of these sectors. Access to critical electric infrastructure, especially in areas of utility grind network or power generation capacity constraints, is a prerequisite in attracting these industries and retaining them in the State, as well as meeting their growing electricity needs.

Fuel cells are uniquely qualified to serve these 24-7-365 needs. Due to high operating efficiency and continuous operation, fuel cell systems generate electricity that is cleaner than the utility grid network - resulting in reduced GHG emissions and current building decarbonization, as demonstrated by substantial data and in CPUC reports from the Self-Generation Incentive Program. [8]

D. Renewable Gas Is a Critical Decarbonization Pathway

The development of the renewable gas market is an important goal to enable the broadest future building decarbonization. True market transformation and decarbonization can only be achieved by investing in both electrification and the development of renewable gas sources. There are fuel cell systems being used in buildings today that can use these renewable fuels and these are only constrained from becoming zero GHG emissions by the availability of renewable fuels. The lack of a renewable gas market for non-transportation use

[8] *SGIP 2016-2017 Self-Generation Incentive Program Impact Evaluation Report.* Submitted by Itron to Pacific Gas & Electric Company and the SGIP Working Group, September 28, 2018. Available at: https://www.cpuc.ca.gov/General.aspx?id=7890

is limiting both the market and the significant GHG, criteria air pollutant and toxic air contaminant emission reductions that can be uniquely achieved by the use of continuous power fuel cell systems.

The NFCRC agrees with the EDF workshop presentations that renewable gas is a critical decarbonization pathway and should be considered in CEC gas and electricity planning, as a way to transition to zero emission buildings using existing infrastructure. The development of the renewable gas market is an important goal to enable the broadest future building decarbonization. There are fuel cell systems being used to decarbonize buildings today that can use these renewable fuels and are only constrained by the availability of the fuels, limiting both the market and the significant GHG, criteria air pollutant and toxic air contaminant emission reductions that can be uniquely achieved by the use of continuous power fuel cell systems.

It is likely that decarbonization of both the gas and electric grids will be the most cost-effective means for achieving the 100% zero emissions goals of California. In other jurisdictions that are considering 100% renewable electricity generation, they are not considering the electrification of all end-uses, but rather some electrification (where it makes most sense, e.g., new construction) and some renewable hydrogen production, transmission, and distribution (where it makes most sense, e.g., for very much lower retrofitting costs and help with energy transmission and seasonal storage). For example, the northern U.K. has initiated a number of projects to explore and demonstrate the complete conversion of their gas system to deliver renewable hydrogen produced from off-shore wind to all current residents with gas service.[9,10] They have determined that this decarbonization of both gas and electricity will likely be most cost effective and implementable.[11,12] Renewable wind and solar power generation, fuel cells operating on natural gas, biogas, and renewable hydrogen, and energy storage technologies can all reduce CO_2 and other GHG emissions. **Through the fuel flexibility of fuel cells, and the ability to operate continuously and follow fluctuating electrical (and thermal) loads, fuel cell systems can also provide a critical role in enabling decarbonized buildings.** The growing market and increasing deployment of fuel cell systems, however, are hindered by changing and new regulatory and policy hurdles associated with the availability and development of renewable gas supplies for distributed power generation. Promisingly, solar and wind resources are well-positioned to produce large amounts of renewable hydrogen via a power-to-gas water electrolysis process. The scientific community is increasingly recognizing the important and required role for renewable hydrogen and its derivatives for achieving a zero emissions economy as indicated in a recent *Science* publication.[13] Storage, transmission, distribution, and end-use of this renewable and sustainable hydrogen fuel in the existing gas system may comprise the most cost-effective means of achieving massive and seasonal storage of renewable electricity.

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[9] Diego Arguedas Ortiz, BBC, "How hydrogen is transforming these tiny Scottish islands," http://www.bbc.com/future/story/20190327-the-tiny-islands-leading-the-way-in-hydrogen-power, 28 March 2019.
[10] Energy Networks Association, "Putting the H100 into hydrogen – demonstrating hydrogen networks, http://www.energynetworks.org/blog/2017/12/19/putting-the-h100-into-hydrogen-demonstrating-hydrogen-networks/, 19 December 2017.
[11] Arup and Kiwa Gastec appointed to explore potential for using hydrogen to heat UK homes, https://www.arup.com/news-and-events/arup-and-kiwa-gastec-appointed-to-explore-potential-for-using-hydrogen-to-heat-uk-homes, 9 November 2017.
[12] Joanna Sampson, GasWorld, £25m project to explore potential for using hydrogen to heat UK homes underway, https://www.gasworld.com/project-to-explore-using-hydrogen-to-heat-uk-homes-underway/2013778.article, 9 November 2017.
[13] Davis, S., N. Lewis, M. Shaner, S. Aggarwal, D. Arent, I. Azevedo, S. Benson, T. Bradley, J. Brouwer, Y-M. Chiang, C. Clack, A. Cohen, S. Doig, J. Edmonds, P. Fennell, C. Field, B. Hannegan, B. Hodge, M. Hoffert, E. Ingersoll, P. Jaramillo, K. Lackner, K. Mach, M. Mastrandrea, J. Ogden, P. Peterson, D. Sanchez, D. Sperling, J. Stagner, J. Trancik, C-J. Yang, K. Caldeira, *Net-zero emissions energy systems*, Science, Vol. 360, Issue 6396, 29 June 2018.

Doosan is currently installing a 50 MW stationary fuel cell system in Korea that will be fueled solely by hydrogen. The hydrogen is a by-product of a petrochemical plant that will be used to operate the fuel cell system with the utility utilizing the electricity produced.

In New York, Bloom Energy has installed multiple fuel cell projects as part of the Con Edison Brooklyn Queens Demand Management and Demand Response Program.[14] The program ultimately avoided nearly $1 billion in ratepayer costs through the use of targeted distributed generation installations. The Program projects include one using solar, storage, and fuel cell technologies together at a low-income housing development, to optimize the efficiency, reliability, and affordability of the project.

III. Closing Comments

The NFRC appreciates the opportunity to comment on the Joint Agency Workshop on Energy Efficiency and Building Decarbonization as part of the 2019 Integrated Energy Policy Report (IEPR) docket and recommends that the CEC use of variety of distributed generation and storage technology to decarbonize buildings in California. Fuel cell systems and renewable gas should be part of the recommended strategy and should be a major part of any discussion on decarbonization of the entire economy. In addition, the IEPR should explicitly recommend those

[14]Brooklyn Queens Demand Management Demand Response Program available at: https://www.coned.com/en/business-partners/business-opportunities/brooklyn-queens-demand-management-demand-response-program

decarbonization technologies that also reduce air pollutants and increase resiliency, both of which have direct positive impacts on all California communities.

Respectfully submitted,

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