DOCKETED	
Docket Number:	18-IEPR-05
Project Title:	Climate Adaptation and Resiliency
TN #:	225769
Document Title:	Jack Brouwer - National Fuel Cell Research Center Comments NFCRC Comments on Draft 2018 IEPR Update, Volume II
Description:	N/A
Filer:	System
Organization:	Jack Brouwer/National Fuel Cell Research Center
Submitter Role:	Public Agency
Submission Date:	11/2/2018 1:30:46 PM
Docketed Date:	11/2/2018

Comment Received From: Jack Brouwer/National Fuel Cell Research Center
Submitted On: 11/2/2018
Docket Number: 18-IEPR-05

NFCRC Comments on Draft 2018 IEPR Update, Volume II

NFCRC comments attached on Draft 2018 IEPR Update, Volume II (Docket 18-IEPR-05).

Additional submitted attachment is included below.

NATIONAL FUEL CELL RESEARCH CENTER

University of California, Irvine
Irvine, California 92697-3550
(949) 824-1999
(949) 824-7423 Fax
http://www.nfcrc.uci.edu

November 2, 2018

California Energy Commission
Dockets Office, MS-4
Re: Docket No. 18-IEPR-01
1516 Ninth Street
Sacramento, CA 95814-5512

Subject: Draft 2018 Integrated Energy Policy Report Update Volume II:

1. **Docket Number 18-IEPR-01- General/Scope**
2. **Docket Number 18-IEPR-03 - Southern California Energy Reliability**
3. **Docket Number 18-IEPR-05 - Climate Adaptation and Resiliency**
4. **Docket Number 18-IEPR-06 - Increasing Flexibility in the Electricity System to Integrate More Renewable Energy**
5. **Docket Number 18-IEPR-09 - Decarbonizing Buildings**

The National Fuel Cell Research Center (NFCRC) submits these comments on the Draft 2018 Integrated Energy Policy Report (Draft IEPR) Update Volume II, released in October 2018 by the California Energy Commission (CEC).

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.

UCI
University of California, Irvine

II. Comments

The NFCRC reaffirms the recognition that the grid requires additional support to increase the penetration of renewable generation sources, while maintaining resiliency and reliability. Key technologies that are required include electric batteries, hydrogen, and clean 24/7 load-following power generation, capable of eventually operating on renewable hydrogen.

California's energy strategy should include fuels, heat, and power generation sources that provide grid services; reduce greenhouse gases, criteria pollutant emissions, water and land usage and waste; and improve resiliency, efficiency, and air quality.

Fuel cell systems exhibit all of these clean energy attributes. They are highly efficient power generation sources that can, in addition, produce heat, cooling, and hydrogen with highly-valued resiliency. Fuel cell systems maintain operation during grid outages, providing significant economic and community benefits. Additionally, because fuel cells generate power electrochemically rather than by combustion, they produce virtually zero criteria pollutant emissions.

From a power generation perspective, technologies that can additionally provide load-following and ramping, and enhance both onsite generation and assist utilities in managing a high penetration of renewable generation, should be preferred for increased reliability, resiliency and emission reduction. [1]

A. CHAPTER 1: Decarbonizing Buildings (Docket Number 18-IEPR-09)

The CEC 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[2] is already being realized today by using fuel cell systems. 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

[1] Advanced Power and Energy Program at the University of California Irvine, "*Managing the Dynamics of a 100 Percent Renewable Electric Grid*" March 2018 available at: http://www.apep.uci.edu/Research/whitePapers/pdf/APEP_Grid_Management_3-Page_031518.pdf

[2] Draft 2018 IEPR Update Volume II, at 33.

from 55% to 80%[3] and, with a superior design and well-matched loads, exceeding 90%.[4] 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.[5]

Renewable Gas

The NFCRC agrees with SoCalGas and SMUD[6] that renewable gas for electrification should be considered in CEC gas and electricity planning, as a way to transition to zero emission buildings using existing infrastructure.

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 greenhouse gas (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.

In summary, for the grid as a whole, fuel cells offer substantial benefits including:

(1) critical and necessary 24/7, load-following complement to electric battery and hydrogen storage in order to manage the diurnal variation and intermittencies associated with solar and wind

(2) the ability to operate on renewable gas, hydrogen, and natural gas

---

3 Darrow, K., et al., Catalog of CHP Technologies 2015: Available at: https://www.epa.gov/chp/catalog-chp-technologies (Accessed January 12, 2015).

4 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.

5 *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.

6 Draft 2018 IEPR Update Volume II, at 31.

(3) increased energy efficiency
(4) firm 24/7, load-following power
(5) an increase in resiliency through local power generation in microgrids
(6) reduction or elimination of greenhouse gas emissions and short-lived climate pollutants
(7) virtually zero emission of criteria pollutants
(8) zero to significantly reduced water use
(9) promoting energy security through energy diversity

Fuel cells for power and heat generation are among the largest consumers of directed biomethane outside of the transportation sector. The guarantee of a growing and reliable supply of biomethane and other forms of renewable gas is of crucial importance to these consumers. The current market, however, strongly favors the use of renewable gas in the transportation sector. Federal policies have established a Renewable Identification Number (RIN) that can be assigned to a batch of biofuel for the purpose of tracking its production, use and trading as required by the United States Environmental Protection Agency's Renewable Fuel Standard (RFS). Current RIN prices allow biogas developers to generate around $30/MMBtu for the RIN value alone if they sell their product in the transportation market. Selling the same biogas into the electricity market would not generate a RIN, and the developer would thus forgo this lucrative federal incentive (worth more than the biogas itself).

The NFCRC contends that directing the majority of the biogas supply to the transportation market for use in natural gas engines may not capture the most air quality benefits. The Union of Concerned Scientists recently released a report highlighting that "*while biomethane generates lower global warming emissions than natural gas when used in CNG vehicles, it produces even lower emissions when used to make electricity … likewise [this] results in lower emissions of smog-forming nitrogen oxides than using biomethane directly in a CNG vehicle*."[7] We understand that the Commission cannot change federal policy, but, **the NFCRC urges Commission consideration of incentives in the IEPR that would encourage the cleanest (lowest emissions) and most efficient use of biogas.**

[7] Union of Concerned Scientists, "*The Promises and Limits of Biomethane as a Transportation Fuel*," available on-line at: https://www.ucsusa.org/sites/default/files/attach/2017/05/Promises-and-limits-of-Biomethane-factsheet.pdf, May, 2017.

B. CHAPTER 3: Increasing Flexibility in the Electricity System to Integrate More Renewable Energy (Docket Number 18-IEPR-06)

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 GHG reductions when integrated with renewables.

On the utility side of the meter, fuel cells today provide clean generation and grid support at the distribution level and can provide 24/7, dispatchable power generation (using any gaseous fuel), and renewable power generation (when using renewable gas) to complement a high penetration of intermittent, diurnal and seasonal varying wind and solar.

With a substantial deployment of intermittent and diurnal varying renewables with low capacity factors, California is experiencing challenging grid stability issues and gaps in power generation. The use of short-duration energy storage technologies (predominantly lithium ion battery systems) to address these gaps is helpful, but, it has resulted in increased emissions on the California grid.[8] Reversible fuel cells or electrolyzers can also serve as a controllable load that correspondingly helps the grid manage instances of overproduction from renewable resources to produce a renewable hydrogen fuel for storage and later electricity production or for use in fuel cell vehicles. **While battery energy storage is necessary and good, the inclusion of clean, 24/7 load-following generation is also required for a successful conversion to 100% clean energy.**[9] Fuel cells are perfectly suited to serve this role.

Benefits of fuel cell systems include the provision of 24/7, clean, load-following power at close to 100% capacity factors. Importantly, this high capacity factor corresponds to the production of clean, renewable electric energy (MWh) per unit of power capacity (MW) that is on the order of six (6) times that of solar power systems

[8] Itron, Energy + Environmental Economics (E3), 2017 SGIP Advanced Energy Storage Impact Evaluation, available on-line at: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/Customer_Gen_and_Storage/2017_SGIP_AES_Impact_Evaluation.pdf

[9] Davis, *et. al., Net-Zero Emissions Energy Systems,* Science **360**, 1419 (2018) 29 June 2018

(assuming a 15% capacity factor for solar) and on the order of three (3) times that of wind power systems (assuming a capacity factor of 30% for wind). Thus, investments in fuel cell capacity produce vastly more renewable energy than wind or solar power systems per unit of capacity installed. Unlike investments in solar and wind power systems, installations of fuel cell systems can be used by the utility to (1) support local capacity and spinning reserve requirements that are used for grid reliability, and (2) serve as an alternative to costly utility system transmission and distribution upgrades. In addition to mitigating carbon emissions when utilizing natural gas and biogas, and eliminating carbon emissions when operating on renewable hydrogen, fuel cells generate and emit virtually zero criteria pollutants in contrast to traditional combustion-based power generation options. Also, 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.

Renewable Hydrogen in the 100% Clean Grid

Ensuring that a diversity of primary energy sources is available to enable the 100% clean grid in the future is critical to address the realistic integration of distributed resources. Renewable hydrogen fuel, including hydrogen as a blend stock or secondary component of methane, renewable methane and hydrogen fuel can be produced from many renewable sources including biogas, other renewable gas derivatives, and by renewable powering of water electrolysis in power-to-gas applications. **Renewable hydrogen should thus be considered in the IEPR to enable the 100% clean grid.**

NFCRC research has determined that hydrogen is critically needed to address both the stationary power and transportation goals of the State, for many reasons. First, hydrogen offers one of the only economic means for zero emission long-duration (e.g., seasonal) storage of renewable power. Second, hydrogen can be produced in much larger quantities than all other renewable gases to meet a much larger fraction of the otherwise difficult to electrify end-uses (such as long-haul freight, aviation, marine transport, and district heating). Third, hydrogen offers zero GHG and zero criteria pollutant conversion options in both its production and end-use. Fourth, there are fuel cell systems available today that can use these renewable fuels and are only constrained by the availability of these fuels, which limits 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. Organic feedstocks are more limited than solar and wind resources, which are technically able to produce large amounts of renewable hydrogen via a power-to-gas 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.[10]

Energy Storage Procurement

As the fraction of renewable energy on the grid increases, the need for storage technologies of durations in excess of six hours will become vital. This is evidenced by a recent U.S. Department of Energy Federal Opportunity Announcement seeking storage solutions with durations of 10 to 100 hours and numerous recent studies forecasting that long-duration storage will be essential to the integration of high fractions of renewables.[11] Lithium ion (Li-ion) technology is not likely to be suitable for addressing this need due to a fixed power-to-energy capacity ratio that is also typically greater than one (i.e., a 10 MW Li-ion battery typically can deliver less than 10MWh of energy). In addition, there are resource concerns regarding global lithium and cobalt supply, given the dramatically growing demand for Li-ion technology in transportation and many other applications. The limited supply is already leading to increased lithium and cobalt commodity prices, and NFCRC research suggests that the storage requirements of renewable utility grid networks will far outstrip global lithium and cobalt reserves if it were to all be served by Li-ion batteries.[12] The goal of transforming the energy storage market cannot be fully

---

[10] 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.

[11] U.S. Department of Energy Advanced Research Projects Agency-Energy (ARPA-E) Funding Opportunity Announcement *DE-FOA-0001906: Duration Addition to Electricity Storage (Days).* Available on-line at https://arpa-e-foa.energy.gov/#FoaIdc931d71c-1e66-4fea-8a27-91860bcd781d July 2, 2018.

[12] Tirado, Nuria, "Resource, recycling and waste challenges for storage resources in a 100% renewable economy," Senior Thesis – Chemical Engineering, B.Sc. advisor: Jack Brouwer, Escola d'Enginyeria de Barcelona Est – Universitat Politècnica de Catalunya, University of California – Irvine, Balsells Mobility Program, 2018.

achieved unless it begins to include significant deployment of technology to meet the range of necessary use cases.

Hydrogen storage technologies can offer specific and desirable technological features that are different than Li-ion batteries. These features could include systems that can: (1) transmit and distribute energy without any additional investments in electric transmission and distribution infrastructure; (2) consume electricity in locations disparate from electricity production; (3) store energy for seasons without self-discharge; and (4) produce fuels that can be used in various transportation and industrial applications.

The IEPR must recognize and acknowledge hydrogen as a long-duration storage medium. Hydrogen is a versatile energy carrier that, relatively speaking, can be transported and stored in very large quantities (terawatt hours if geological storage is used) and over long durations (up to months and years) with no self-discharge. Devices for converting electrical energy to hydrogen and later returning the energy to the grid, like electrolyzers and fuel cell systems, have grid-beneficial attributes including abilities to provide load following, power quality, ancillary services, and siting flexibility. In addition, both the production and conversion of hydrogen under these circumstances is completely free of criteria pollutant and greenhouse gas emissions. This paradigm also allows siting of the electricity consuming (hydrogen production) facilities in locations that are disparate from the electricity production (hydrogen consuming) facilities. For example, electrolyzers could be sited in the desert where excess solar or wind power is available, while the fuel cells could be sited in a city near major loads.

These attributes are not fully valued in present resource valuation methodologies because the relevant market structures are nascent and because methods are not fully developed for assessing the total value to the grid of long-lived, utility-owned resources of these types. In some cases, the unique energy storage features of hydrogen energy storage actually preclude them from participating (e.g., disparate points of charging and discharging interconnection are not currently allowed in the CAISO market). Furthermore, electrolytic hydrogen resources can be dispatched for vehicle fuel production or pure electric storage functionality. Electric-utility procurement valuation methodologies, however, do not account for the potential cost optimization of economic dispatch to either fuel or power. Such use cases cross jurisdictional boundaries, but should be considered both viable and desired in the same manner as vehicle electrification is being considered. In fact, using electrolytic hydrogen in fuel cell electric vehicles is exactly electrification of transportation with inherent storage.

Finally, the advancement of state policy outside the electric sector (additional cost-effective hydrogen production resources for vehicles, rail, marine and port) is not reflected in current procurement priorities.

A key lesson learned in California is that electric battery energy storage has increased greenhouse gas (GHG) emissions in the State. After converting the majority of the California Self Generation Incentive Program to funding battery energy storage projects, in 2017 the California Public Utilities Commission ("CPUC") released a report showing the increase in GHG emissions that was especially due to the time of use dispatch of short-duration storage projects. The report noted the following:

> "While the evaluation's findings indicate that SGIP is generally helping to reduce system peak demand, customer peak demand and customer bills, a key goal of the SGIP program is to reduce greenhouse gas (GHG) emissions, which is not currently being met. The evaluators believe that this is principally due to rate designs that are misaligned with peak marginal GHG hours, which prevent customers from receiving signals that would lead to GHG reductions. The evaluation also reveals other system performance issues that require attention. These include data availability for residential and certain small non-residential systems, low efficiency and increased system peak demand arising from smaller systems, and renewable integration for all systems." [13]

There is also a critically important need to identify the manner by which clean power generation and energy storage are dispatched on the utility grid network. For the most part, clean power generation is today dispatched as a base-load resource due to the financial incentives that promote the 24 hours/day 7 days/week (24/7) continuous operation of the equipment to garner the best rate of return on investment. However, if rate structures were developed to provide a financial incentive for clean power generators to operate dynamically, producing more power during some times of the day and less during others, then the inherent capabilities of clean power generators to operate dynamically would be exercised by those participants fulfilling the storage mandate.

---

[13] *2016 SGIP Advanced Energy Storage Impact Evaluation Impacts Evaluation Report.* Submitted by Itron to SoCalGas and the SGIP Working Group, August 31, 2017. Available at: http://www.cpuc.ca.gov/sgip/ at Foreword.

The Advanced Power and Energy Program at the University of California, Irvine has submitted detailed comments to the CPUC Distributed Generation proceeding docket that contain detailed analyses.[14] These analyses establish that battery energy storage systems dispatched by participants in the SGIP program are dispatched in a manner to receive the best rate of return on investment. Because these systems store energy rather than produce power, there are certain times of the day in which they consume electric power and other times of the day in which they discharge electric power. These systems are typically charged at night when time-of-use (TOU) electric rates are low and discharged during the day when TOU rates are high, making battery energy storage use for energy arbitrage more financially attractive. Additionally, if battery energy storage systems charge between the hours of 11:00pm and 8:00am and then discharge between the hours of 8:00am and 5:00pm, the result is to shift less renewable power from the night to the day and also exacerbate the potential for renewable power over-generation and curtailment. This unfortunate set of conditions has led to the fact that battery energy storage systems are today performing a negative function on the grid in California, leading to increased grid dynamics and actually increasing the GHG emissions of the grid.

Finally, there is a critically important need for work on rate structures in order to enable economic operation of both energy storage and clean power generators in a manner that best supports the introduction of more renewables and supports grid reliability, resiliency, and sustainability. **The NFCRC strongly encourages the CEC to recommend incentivizing charging during periods of high (excess) renewable power generation and discharging during periods of low renewable power generation and high demand (e.g., winter evening peak demand period)[15] in the IEPR.** Similarly, clean power generation rate structures are required to incentivize turn-down of power generation when renewable power generation is high (excess) and ramp-up of power generation when renewable power is low and demand is high. In addition, for both energy storage and clean power generation, rate structures must be developed and

[14] R-12-11-005. *Order Instituting Rulemaking Regarding Policies, Procedures and Rules for the California Solar Initiative, the Self-Generation Incentive Program and Other Distributed Generation Issues*. Comments of the Advanced Power and Energy Program at the University of California, Irvine. June 6, 2016.
[15] Roadmap at 31.

implemented that value the ramping capabilities of both technologies and provide utilities with the tools to incentivize and/or introduce these technologies to the markets that value ancillary services (e.g., Volt-VAR support, frequency regulation).

C. CHAPTER 5: Climate Adaptation and Resiliency (Docket Number 18-IEPR-05) Public Safety Priorities: Critical Facilities

Chapter 5 of the Draft IEPR suggests only solar and storage as a replacement for diesel generators. Battery energy storage alone will not create robust, low-emissions resiliency that is required while transitioning to expanding renewables on the grid and through more frequent climate events. Battery energy storage systems can never guarantee a full state-of-charge and thus may not be able to deliver the required back-up generation. On the other hand, clean, firm power generation sources (i.e., hydrogen storage plus fuel cells) can guarantee back-up power availability so that these systems are also needed for the complete transition to 100% clean and renewable energy.

Fuel cell systems are fuel flexible. While hydrogen is the ideal fuel for fuel cells, fuel cells can also operate on natural gas, biogas, or propane. A viable approach today and for the transition to renewable hydrogen is the utilization of natural gas, given its high reliability and availability and relatively low cost, and the high efficiency and reduced emissions of fuel cells relative to combustion systems and diesel generators, even when operating on natural gas. Fuel cells are zero-emission with respect to nitrogen oxides, carbon monoxide, sulfur oxides, and particulate matter, and they emit less GHG when operating on natural gas (as opposed to the combustion of natural gas), and fuel cells produce zero carbon when operating on renewable gas.

The risks created by intermittent and diurnal varying power generation resources, such as wind and solar power, are primarily related to over-and under-generation. By using distributed, 24/7, load-following power generation resources, these risks can be mitigated. Another challenge associated with variable energy resources includes voltage and frequency instabilities in the utility grid network that can be caused by a high use of inverters that have no inherent rotating inertia, and are not currently allowed to inject or absorb reactive power to simulate such. **Fuel cell systems should be prioritized in the IEPR as a replacement today for diesel generators and as necessary for a resilient,**

100% clean grid. The NFCRC also encourages CEC consideration and study of smart inverters and converters that can help the utility manage voltage and frequency.

Microgrids

A variety of distributed generation resources are essential to a resilient infrastructure that also avoids transmission and distribution losses, costs and risks. Microgrids combine these resources and are becoming an essential strategy to meet both GHG and air pollution reduction goals, while enhancing reliability and resiliency, and increasing renewable generation on the grid as a whole.

In contrast to combustion technologies, fuel cells have attributes that are perfectly situated for a microgrid: quiet, virtually zero emission of criteria pollutants, and high quality heat. 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). These microgrids can therefore create strong resiliency and reliability on the grid in the event of disasters or grid instability. Stand-alone fuel cell systems as DER can also create resiliency outside of a microgrid and provide continuous clean power in addition to islanding connection to critical loads onsite. 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.

As discussed in the above comments on Integrating Renewables (Docket 18-IEPR-06), an increase in renewable resources requires 24/7, baseload, load-following power generation to mitigate intermittency from seasonal and diurnal variation of solar and wind power. Microgrids that use fuel cells integrated with renewable resources create a firm, highly reliable and zero emission microgrid. A microgrid's fuel cell enhanced reliability is even more important when considering the recent increased adoption throughout the state of intermittent renewable wind and solar resources which only supply power when the wind blows or the sun shines. Additionally:

> "Those in search of reliable energy also are likely to find it easier and quicker to site a fuel cell microgrid than many other energy resources. Compared with fossil fuel-fired plants, wind, or solar farms, fuel cells are relatively easy to site. They do not require specialized orientation to operate, or wide swaths of land. They can be sited either outdoors or indoors. This means that fuel cell microgrids are more

> likely to be accepted within communities, especially in densely populated areas where microgrids are often deployed to bolster grid resilience and reliability... The flexibility and continuous output of fuel cells make them an ideal partner for microgrid installations that seek increase grid reliability while maintaining strict environmental standards."[16]

The IEPR should encourage the use of fuel cell systems in microgrids for clean reliability and resiliency. Beyond electric generation, the IEPR should acknowledge that dependence upon a single storage solution creates risk of supply shortages of the necessary materials and also creates a risk for the lack of deployable and cost-effective solutions to meet storage functions (e.g., long-term storage) that are not easily provided by the most widely used Li-ion technology. In addition, the resiliency that is desired by utility grid networks will be inhibited by deployment of only one storage technology, especially one that is vulnerable to some forms of attack (e.g., electromagnetic pulse). Finally, meeting grid capacity constraints can be accomplished by installation of energy conversion devices that are fueled (e.g., fuel cells fueled by gaseous fuel), but cannot be provided by Li-ion battery energy storage that could have a limited state of charge at any given moment in time.

D. CHAPTER 6: Southern California Energy Reliability (Docket Number 18-IEPR-03)

A modern grid that includes distributed generation to reduce or eliminate combustion, can adapt and respond with resiliency to the impacts of climate change (e.g., extreme weather events) if appropriately designed. Additionally, the most immediate, direct, and daily impacts on California and its citizens are not associated with climate change but rather with air quality. Power generation produced through natural gas combined cycle (NGCC) power plants today meets the majority of electricity demand, but with the concomitant emission of criteria pollutants (e.g., NOx), low efficiencies limited by heat engine constraints, inability to capture heat, and losses due to long distance transmission and distribution of the electricity. When using natural gas, fuel cells reduce GHG emissions compared to generation from the current grid and generate virtually zero criteria pollutant emissions. When operated on biogas (or other renewable fuel), fuel cells generate electricity and heat with zero net carbon

[16] Microgrid Knowledge, "*Fuel Cell Microgrids: The Path to Lower Cost, Higher Reliability, Cleaner Energy*" copyright 2017, Energy Efficient Markets, LLC.

emitted. Fuel cells are also capable of operation on renewable hydrogen with a zero emission of both carbon and criteria pollutants.

Preferred Resources

The IEPR should consider utility-scale procurements in Southern California of reliable, non-combustion, efficient, and load-following resources such as fuel cell systems – which are a Preferred Resource in California. As a fundamental element of large-scale procurements, fuel cells provide unique co-benefits.[17] Fuel cell systems are already deployed today in many jurisdictions on the utility-side of the meter to create grid support solutions where transmission or distribution is constrained or where increased reliability is sought. These resources are providing clean, 24/7, load-following power generation to complement the increasing deployment of intermittent solar and wind resources, and to 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.

Korea is using hundreds of MW of fuel cell systems to modernize their grid. [18] Fuel cell attributes more effectively meet the Korean renewable portfolio standard (RPS) goals than intermittent wind and solar resources. Also, in densely populated areas, land constraints limit large-scale implementation of some renewable resources such as wind and solar, whereas fuel cells can be installed within a very small footprint. These fuel cell systems function like substations providing primary power and heat, even when the grid goes down. For example, in Korea, Doosan has installed 30.8 MW of fuel cells for district heating and electricity for 71,500 homes in the City of Busan. This system can also operate when the grid goes down and is configured in a tiered structure and sited on only one acre of land; an equivalent 30 MW solar farm could require more than 75 acres and would produce as little as $1/6^{th}$ the amount of electric energy and zero heat.

---

[17] 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, at 178-186.

[18] International Energy Agency and International Renewable Energy Agency Joint Policies and Measures Database available at: https://www.iea.org/policiesandmeasures/pams/korea/name-39025-en.php?s=dHlwZT1yZSZzdGF0dXM9T2s&s=dHlwZT1yZSZzdGF0dXM9T2s

Another example is a 59 MW FuelCell Energy power plant located at Gyeonggi Green Energy south of Seoul, Korea. This system produces 440 million kilowatt-hours of electricity per year and supplies district heating, all on just 5.2 acres of land.

Doosan is currently installing a 50 MW 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 projects as part of the Con Edison Brooklyn Queens Demand Management Demand Response Program. [19] 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.

Fuel cell systems should be installed for the express purpose of supporting capacity needs throughout the utility grid network. While improving reliability, these types of DER are also capable of avoiding line losses, as well as transmission and distribution costs. Rate structures should be developed to compensate clean, load-following resources that provide increasingly valuable ancillary services such as ramping, capacity, spinning reserve, and voltage and frequency support to the utility grid network. The exact purpose for installing and operating fuel cell systems in a highly dynamic environment is to directly complement intermittent renewable power generation, and improve the reliability and stability of a grid utilizing a high penetration of renewable power generation.

III. Closing Comments

The NFRC appreciates the opportunity to review and comment on the Draft 2018 Integrated Energy Policy Report (Draft IEPR) Update Volume II and recommends that the CEC integrate a variety of distributed generation systems on the grid, in addition to solar, wind and storage for increased resiliency and reliability. Fuel cell systems should be part of the strategy recommended to decarbonize buildings and should be a major part of any discussion on decarbonization of the entire economy. In addition, the removal of combustion to ensure direct

[19]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

community impact by reducing air pollutants and air toxics and improving air quality should be explicitly recommended in the IEPR.

Respectfully submitted,

Dr. Jack Brouwer
Director
National Fuel Cell Research Center
University of California, Irvine
Irvine, CA 92697-3550
Tel: 949-824-1999 Ext. 11221
E-mail: jb@nfcrc.uci.edu