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February 10, 2021

Via Electronic Mail

Hon. Patrick Woodcock
Chair, Energy Efficiency Advisory Council
Commissioner, Massachusetts Department of Energy Resources
100 Cambridge Street, Suite 1020
Boston, MA 02114

Re: 2022 – 2024 Three-Year Energy Efficiency Plan

Dear Commissioner Woodcock,

The National Fuel Cell Research Center (NFCRC) respectfully submits comments to the Energy Efficiency Advisory Council (EEAC or the "Council") on the development of the 2022-2024 Three-Year Energy Efficiency Plan for the Mass Save programs.

I. INTRODUCTION

The NFCRC facilitates and accelerates the development and deployment of fuel cell technology and 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 power and energy storage sectors. The NFCRC was established in 1998 at the University of California, Irvine by the U.S. Department of Energy and the California Energy Commission in

order to develop advanced sources of power generation, transportation and fuels and has overseen and reviewed thousands of commercial fuel cell applications.

The NFCRC notes Councilor comments from the December 1, 2020 meeting of the Massachusetts Energy Efficiency Advisory Council that question the focus of plans upon solely combustion-CHP technology.[1] The NFCRC supports the Councilor recommendations to:

- **Include fuel cells in the program impact evaluation; and**
- **Assess how fuel cells and hydrogen can help Massachusetts meet its resiliency, climate, air quality, equity, and infrastructure goals.**

II. COMMENTS

Even before the COVID-19 epidemic, a body of evidence was growing that local air pollution is more harmful to human health than previously understood. Air pollution exposure is connected to increased risk of brain cancer, increased glaucoma risks, increased risk of ischemic stroke, heart failure, and preterm birth. Chronic exposure to air pollution is equivalent to smoking a pack of cigarettes a day. Attached to this testimony is a more complete list of over 15 new studies on the serious health impacts of locally generated combustion related pollutants. *All of these studies were released within the last 24 months*.

An additional and even newer area of evidence involves COVID-19 and its impacts on disadvantaged communities that are impacted disproportionately by locally generated combustion related pollutants. Although the studies have yet to be peer-reviewed and are therefore not yet final, Harvard researchers have recently reported that a long-term air pollution increase of 1 microgram per cubic meter of small particles can raise the risk of dying from COVID-19 by 15%.

[1] Massachusetts Energy Efficiency Advisory Council, Final Meeting Summary, December 1, 2010 at 12-13. Available at: EEAC-Workshop-3-Summary-12-1-2020_FINAL.pdf (ma-eeac.org)

Separately, University of Siena researchers assert that because air pollution "impairs the first line of defense" of the upper respiratory tract, it likely explains why those who live in areas with higher air pollution fall prey to the disease more than others. Taken together, these findings highlight what we already know – without access to clean air, otherwise at-risk communities are more likely to contract this disease and many other illnesses.

The use of fuel cell systems, hydrogen and renewable gas has a significant impact on the reduction of criteria air pollutants and air toxics as well as greenhouse gas (GHG) emissions, making these technologies important solutions to advance Massachusetts' energy efficiency goals while also addressing air quality and environmental justice issues.

A. Fuel Cell Systems

Fuel cells are uniquely qualified to serve 24-7-365 power generation as well as backup generation requirements. Due to high operating efficiency and continuous operation, non-combustion fuel cell systems generate electricity that is cleaner than the utility grid network—resulting in reduced GHG emissions.

The fuel cell industry provides significant benefits to its customers in the form of lower emissions, resilience, and the ability to island from the grid. Many fuel cell installations operate as behind-the-meter projects, at commercial, industrial or critical facility sites, meaning that they are configured to provide onsite power with little or no exports to the distribution system. As such, it is a primary concern of NFCRC that distributed energy resources (DER) be valued appropriately for the benefits that they provide to the grid. For example, an electron generated by a zero emitting or low emitting technology makes the energy system of Massachusetts cleaner regardless of whether it is consumed behind the

customer meter or exported onto the distribution system. Similarly, a project can provide load relief with both exported generation and generation consumed behind-the-meter. Both configurations of projects should be compensated for the values that they provide to the grid. ISO New England recognizes this fact and allows behind-the-meter generation and other load reductions, such as energy efficiency and demand response, to participate in its Forward Capacity Market.

Emission Reduction and Local Air Quality

Clean distributed generation, such as that produced by fuel cell systems, has unique features and capabilities to address the need for air quality in geographically diverse communities and serve as alternative power and heat generation sources.

The reductions of carbon and criteria air pollutants from stationary fuel cells can also make a direct positive impact on local communities. Stationary fuel cells can create additional positive local air quality impacts, provide non-intermittent renewable power (when using renewable gas), and support the Commonwealth's broader energy and environmental goals.

Fuel cell systems also displace traditional emergency backup generators (almost exclusively diesel combustion generators) that emit criteria air pollutants and GHG. This feature is especially critical given that poor air quality can be a major issue in economically disadvantaged communities that are often disproportionately burdened by air pollution and risks of COVID-19. By providing always-on zero criteria pollutant emission power, fuel cells can increase adoption of intermittent renewable wind and solar resources throughout

Massachusetts while significantly increasing the generation of decarbonized and pollutant-free electricity.

Load Management, Reliability and Resilience

Both front-of-the-meter and behind-the-meter fuel cell resources are well-suited to resolve transmission and distribution needs. Not only do fuel cell power plants reduce GHG and criteria air pollutants, they are also efficient, compact, quiet and easy-to-site, and are ideal DER solutions where power is needed near a load. Fuel cell DER facilities serve loads and can provide benefits to the utility system at the distribution level, whether literally on the customer premises (behind-the-meter), or in any number of front-of-the-meter applications including:

a) at substation interface points acting as load reducers and providing capacity to the regional transmission and distribution system;
b) on utility circuits leading to key customers;
c) as a primary generation resource enabling operation of a multi-load, multi-customer utility microgrids;
d) under a combination where a normal front-of-the-meter resource can serve a dedicated circuit providing a behind-the-meter service to a critical customer (e.g., a wastewater treatment plant);
e) under a combination where a normal behind-the-meter facility can also provide local load reduction as a front-of-the-meter resource under a Net Energy Metering, Demand Side Management (DSM) or desired export situation.

Fuel cell systems generate 24/7, clean, load-following power at close to 100% capacity factors. Compared to other front-of-the-meter non-wires alternative solutions, the combination of fuel cell high efficiency and extremely high capacity factor results in the displacement of more GHG emissions than equivalent-sized intermittent resources. 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 (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 non-wire solutions produce vastly more energy than wind or solar power systems per unit of capacity installed. When this electric energy is produced at times of low renewable energy availability, the fuel cell systems produce much lower GHG emissions per MWh. This translates into substantially more GHG reductions per MW installed.

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, (2) serve as an alternative to costly utility system transmission and distribution upgrades to this system, and (3) with appropriate rate structures allow dynamic dispatch of the fuel cell systems to enable the grid to integrate more intermittent renewable generation.

Fuel cell systems support the utility grid network and can also provide ancillary services such as:

1. Peak demand reduction;
2. Power quality improvements;
3. Grid frequency and voltage support; and
4. Fast ramping and load-following.

B. Renewable Hydrogen

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 increased market penetration of renewable solar and wind resources on the grid. These features of fuel cell systems allow them to reduce pollutant

emissions and improve air quality over and above the improvements that can be made with solar, wind, and energy storage systems alone.

Renewable hydrogen, including hydrogen as a blend stock or secondary component with methane can be produced from many renewable sources including biogas, other renewable gas derivatives, and by renewable solar or wind powering of water electrolysis in power-to-gas applications. Hydrogen is critically needed to address both the stationary power and the transportation air quality and GHG reduction goals of the Commonwealth, for many reasons. First, hydrogen offers one of the only economic, modular, and geographically flexible 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 industrial 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 using 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.

C. Renewable Gas

The NFCRC would like to emphasize the importance of adopting renewable gas policies and projects that have the greatest environmental impact, enabled by the

development of the renewable gas market. Fuel cell systems used in commercial, industrial and multi-unit residential buildings today 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 these continuous power fuel cell systems.

Significant reductions in upstream short-lived climate pollutants (SLCP) are possible by hydrogen production from biogas (e.g., dairy digester gas) because methane that would otherwise be released into the atmosphere is captured and utilized. This pathway leads to very significant emission reductions, especially in agricultural communities. If solar, wind, or other zero SLCP emitting power generation is used to produce hydrogen for power generation in a fuel cell, then upstream SLCP that would otherwise have been associated with the gas and electric power systems used to produce that same power are eliminated. If the same renewable hydrogen is used as vehicle fuel in fuel cell electric vehicles, then upstream SLCP emissions are reduced that would otherwise have been associated with the petroleum extraction, transport, refining, and end-uses that it displaced. Other pathways by which hydrogen could be used to reduce SLCP emissions are available as well.

D. Microgrids

A modern grid and utility infrastructure incorporates resiliency and microgrids into energy planning. When paired with storage, wind, solar, demand response, and 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 can 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 event 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. Fuel cells can be, but do not need to be, connected to a storage device to provide these and other resiliency benefits.

Many fuel cell systems are currently powering microgrids, and all these installations are providing clean and resilient power that is increasingly important as climate-caused and planned electric grid disruptions and natural disasters intensify. Alternative community generation microgrids are comprised of non-combustion resources that do not emit criteria pollutants and air toxics like solar, fuel cells, and battery energy storage devices. The increased use of these technologies will allow Massachusetts to protect its citizens against extreme weather events and other electric grid outages and reduce the use of diesel generators across the Commonwealth at the local level.

As an example, Mass General Brigham (formerly Partners Healthcare) is using fuel cell systems at multiple locations to provide clean, resilient power that provides uninterrupted service for their critical operations. 4.1 MW of fuel cell systems have been installed with the support of the Massachusetts Alternative Portfolio Standard.[2]

A fuel cell-powered microgrid in the Parkville neighborhood of Hartford, Connecticut provides 100% of electricity for a senior center, elementary school and library; facilities that

[2] Burger, Andrew, *Partners HealthCare Turns to Fuel Cells to Improve Electric Reliability at its Massachusetts Hospitals*, Microgrid Knowledge, March 5, 2019. Available at: https://microgridknowledge.com/fuel-cells-healthcare-bloom-energy/

each can serve as a refuge for residents during emergencies or bad weather. In the event of a major grid outage, the microgrid provides emergency power to the senior center, elementary school and library, as well as to an adjacent supermarket and gas station. Another microgrid with a fuel cell providing baseload and resilient power in Woodbridge, Connecticut supplies power to the grid during regular operation and maintains power during outages for six critical town buildings, including a town hall, a senior center, a public works department, a police department, a fire department, and a library.

Fuel cell systems have additionally been installed as part of the Brooklyn Queens Demand Management Demand Response Program that allows ConEdison to plan for and maintain their infrastructure, while supplying reliable energy during peak periods of high demand in densely populated areas.[3] The program ultimately avoided nearly $1 billion in ratepayer costs through use of targeted DER installations. One project in Brooklyn, New York uses solar, storage, and fuel cell technologies together in a microgrid of a low-income housing development to optimize the efficiency, reliability, and affordability of the project.

III. Conclusion

The NFCRC emphasizes the importance of renewable fuels, hydrogen, and fuel cell systems in addressing - first and foremost - short-term and long-term air quality impacts in disproportionately impacted communities. The NFCRC thus once again encourages the Advisory Council to:

- **Include fuel cells in the program impact evaluation; and**

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

- **Assess how fuel cells and hydrogen can help Massachusetts meet its resiliency, climate, air quality, equity, and infrastructure goals.**

Sincerely,

/s/ Jack Brouwer

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ATTACHMENT A

Air Pollution Studies

Various studies have already described that combustion-related Particulate Matter, including Black Carbon, is associated with lower birth weight[4,5], preterm birth[6,7], and intrauterine growth restriction[8,9].

As if this body of evidence for the deleterious effects of combustion related pollution wasn't enough to spur action a new, and growing body of research now suggest they are more harmful than ever before understood.

- "By optimizing for both [reduction in climate forcing gases and criteria air pollution], energy planners can better prioritize specific power plant retirements and unlock even greater health benefits than with climate policy alone. Rather than creating health benefits as a "co-benefit" of climate action, this kind of co-optimized energy policy can unite the two goals intentionally."[10]

- Researchers, looking to explain the observed detrimental effects of combustion related pollutants on fetal development over and above that which is accounted for by simple maternal exposure, found that Black Carbon crosses the placental barrier, even concentrating at detrimental levels in the earliest stages of pregnancy.[11,12] Ultrafine black carbon particulates are spawned by coal-fired power plants, diesel engines and other sources that burn fossil fuels; inhalation is linked to cancer, respiratory problems and birth defects, according to an EPA website.[13]

- Colorado State University Study Finds Short-term Exposure to air pollution is Strongly Linked with Violent Behavior. The research results show a 10 microgram-per-cubic-meter increase in same-day exposure to PM2.5 is associated with a 1.4% increase in violent crimes, nearly all of

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[4] Pedersen, M. et al. Ambient air pollution and low birthweight: a European cohort study (ESCAPE). *Lancet Respir. Med.* **1**, 695–704 (2013).
[5] Slama, R. et al. Traffic-related atmospheric pollutants levels during pregnancy and offspring's term birth weight: a study relying on a land-use regression exposure model. *Environ. Health Perspect.* **115**, 1283–1292 (2007).
[6] Ritz, B., Wilhelm, M., Hoggatt, K. J. & Ghosh, J. K. C. Ambient air pollution and preterm birth in the environment and pregnancy outcomes study at the University of California, Los Angeles. *Am. J. Epidemiol.* **166**, 1045–1052 (2007).
[7] Rudra, C. B., Williams, M. A., Sheppard, L., Koenig, J. Q. & Schiff, M. A. Ambient carbon monoxide and fine particulate matter in relation to preeclampsia and preterm delivery in western Washington State. *Environ. Health Perspect.* **119**, 886–892 (2011).
[8] Liu, S., Krewski, D., Shi, Y., Chen, Y. & Burnett, R. T. Association between maternal exposure to ambient air pollutants during pregnancy and fetal growth restriction. *J. Expo. Sci. Environ. Epidemiol.* **17**, 426–432 (2007).
[9] Winckelmans, E. et al. Fetal growth and maternal exposure to particulate air pollution-More marked effects at lower exposure and modification by gestational duration. *Environ. Res.* **140**, 611–618 (2015).
[10] Olson, Erik In Climate Action, Don't Neglect Air Pollution, The Breakthrough Institute (2019)
[11] Bové, H., Bongaerts, E., Slenders, E. et al. Ambient black carbon particles reach the fetal side of human placenta. Nat Commun 10, 3866 (2019). https://doi.org/10.1038/s41467-019-11654-3
[12] Royal College of Physicians. Every breath we take: the lifelong impact of air pollution. Report of a working party. London: RCP, https://www.rcplondon.ac.uk/file/2914/download (2016).
[13]EPA, Black Carbon Research, https://www.epa.gov/air-research/black-carbon-research, (Site Accessed Jan 2020)

which is driven by crimes categorized as assaults. Researchers also found that a 0.01 parts-per-million increase in same-day exposure to ozone is associated with a 0.97% increase in violent crime, or a 1.15% increase in assaults. [14]

- Personal Exposure to Particulate Matter Is Associated with Worse Health Perception in Adult Asthma.[15]

- National Institutes of Health, finding that Local Air Pollution Increases Preterm Birth Risk. Researchers examined exposure to sulfur dioxide, ozone, nitrogen oxides, nitrogen dioxide, carbon monoxide and particles. For nearly all pollutants, exposure was more likely to decrease over time, but 7 to 12% of women in the study experienced a higher exposure to air pollution during their second pregnancy. The highest risks were with increasing exposure to carbon monoxide (51%) and nitrogen dioxide (45%), typically from emissions from motor vehicles and power plants; ozone (48%), a secondary pollutant created by combustion products and sunlight; and sulfur dioxide (41%), mainly from the burning of fossil fuels that contain sulfur, such as coal or diesel fuel. [16]

- University of Minnesota Study finds Inequity in consumption of goods and services adds to racial–ethnic disparities in air pollution exposure. On average, non-Hispanic whites experience a "pollution advantage": They experience ∼17% less air pollution exposure than is caused by their consumption. Blacks and Hispanics on average bear a "pollution burden" of 56% and 63% excess exposure, respectively, relative to the exposure caused by their consumption. The total disparity is caused as much by how much people consume as by how much pollution they breathe. Differences in the types of goods and services consumed by each group are less important. PM2.5 exposures declined ∼50% during 2002–2015 for all three racial–ethnic groups, but pollution inequity has remained high. [17]

- Air Pollution May Be As Harmful To Your Lungs As Smoking Cigarettes, Long-term exposure to ambient air pollutants, especially O_3, was significantly associated with increasing emphysema assessed quantitatively using CT imaging and with worsening lung function. Emphysema is considered a smoker's disease. But it turns out, exposure to air pollution may lead to the same changes in the lung that give rise to emphysema. "We found that an increase of about three parts per billion [of ground-level ozone] outside your home was equivalent to smoking a pack of

[14] Jesse Burkhardt et al. The effect of pollution on crime: Evidence from data on particulate matter and ozone, Journal of Environmental Economics and Management (2019). DOI: 10.1016/j.jeem.2019.102267

[15] Maestrelli, P. et al. Personal Exposure to Particulate Matter Is Associated With Worse Health Perception in Adult Asthma. *J Investig Allergol Clin Immunol* 2011; Vol. 21(2): 120-128

[16] Mendola, P. et al. Air pollution and preterm birth: Do air pollution changes over time influence risk in consecutive pregnancies among low-risk women? International Journal of Environmental Research and Public Health, 2019.

[17] Tessum et al. Inequity in consumption of goods and services adds to racial–ethnic disparities in air pollution exposure. *PNAS March 26*, 2019 116 (13) 6001-6006; first published March 11, 2019 https://doi.org/10.1073/pnas.1818859116

cigarettes a day for 29 years," "And so as climate change progresses, we expect that vulnerable populations and — even healthy populations — are going to see increased effects," Brigham says. Chronic respiratory disease (which includes chronic obstructive pulmonary disease and emphysema) is a leading cause of death in the U.S. The World Health Organization estimates that each year 7 million premature deaths around the world are linked to air pollution.[18]Thurston says if these long-term cumulative effects were to be included in policymakers' cost-benefit calculations, "the benefits will even more so outweigh the cost of moving forward on cleaning the air." [19, 20]

- Air pollution may have killed 30,000 people in a single year, study says. Those deaths came even as almost every county in the United States remained within federal air quality standards. That suggests more stringent regulations are needed to protect human health, researchers say. "I think the big conclusion is that lowering the limits of air pollution could delay in the US, all together, tens of thousands of deaths each year," said Majid Ezzati, the study's lead author and a professor of global environmental health at Imperial College London. While researchers were confident in the link between air pollution and death rates, they found that the effect was greatest in areas with lower incomes, in places with a higher proportion of black Americans and in regions where fewer people graduated from high school. This "inequality in mortality burden," researchers wrote, may be explained by systematic challenges faced by those demographic groups, including higher rates of preexisting medical conditions. [21]

- Study Finds MORE THAN 100,000 Americans each year die of heart attacks, strokes and other illnesses caused by air pollution spewed from factories, motor vehicles and even bucolic-seeming farmland, according to a new report that contradicts an EPA panel whose members downplayed the risks during a public meeting last month. "We estimate that anthropogenic $PM_{2.5}$ was responsible for 107,000 premature deaths in 2011, at a cost to society of $886 billion." [22]

- European Society of Cardiology finds that Air pollution causes 8.8 million extra early deaths a year. As a result of these findings, the researchers say that national governments and international agencies must take urgent action to reduce air pollution, including re-evaluating

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[18] World Health Organization, 7 million premature deaths annually linked to air pollution, https://www.who.int/mediacentre/news/releases/2014/air-pollution/en/, March 25, 2014 (Site Accessed May 2020)

[19] Wang M, Aaron CP, Madrigano J, et al. Association Between Long-term Exposure to Ambient Air Pollution and Change in Quantitatively Assessed Emphysema and Lung Function. *JAMA.* 2019; 322(6):546–556. doi:10.1001/jama.2019.10255

[20] NPR, All Things Considered, August 13, 2019, https://www.npr.org/sections/health-shots/2019/08/13/750581235/air-pollution-may-be-as-harmful-to-your-lungs-as-smoking-cigarettes-study-finds

[21] Bennett JE, Tamura-Wicks H, Parks RM, Burnett RT, Pope CA III, et al. (2019) Particulate matter air pollution and national and county life expectancy loss in the USA: A spatiotemporal analysis. PLOS Medicine 16(7): e1002856. https://doi.org/10.1371/journal.pmed.1002856

[22] Andrew L. Goodkind, Christopher W. Tessum, Jay S. Coggins, Jason D. Hill, Julian D. Marshall Proceedings of the National Academy of Sciences, Fine-scale damage estimates of particulate matter air pollution reveal opportunities for location-specific mitigation of emissions, Apr 2019, 116 (18) 8775-8780; DOI: 10.1073/pnas.1816102116

legislation on air quality and lowering the EU's current limits on the annual average levels of air pollution to match the WHO guidelines. [23]

- The Evidence Is Strong: Air Pollution Seems to Cause Dementia [2425]

[23] European Society of Cardiology. "Air pollution causes 8.8 million extra early deaths a year." ScienceDaily. ScienceDaily, 12 March 2019. <www.sciencedaily.com/releases/2019/03/190312075933.htm>.
[24] Carey IM, Anderson HR, Atkinson RW, et al Are noise and air pollution related to the incidence of dementia? A cohort study in London, England BMJ Open 2018;8:e022404. doi: 10.1136/bmjopen-2018-022404
[25] Arron Reuben, Wired, The Evidence Is Strong: Air Pollution Seems to Cause Dementia, May 2019, https://www.wired.com/story/air-pollution-dementia/