Enhancing the Role of Fuel Cells for Northeast Grid Resiliency

February 2015

Fuel Cell &
Hydrogen Energy
Association

Contents

ABOUT THE FUEL CELL AND HYDROGEN ENERGY ASSOCIATION

The Fuel Cell and Hydrogen Energy Association is the trade association dedicated to the commercialization of fuel cells and hydrogen energy technologies, representing the full global supply chain, including materials, components and systems manufacturers, hydrogen producers and fuel distributors, government laboratories and agencies, trade associations, utilities, and other end users.

Executive Summary

Severe weather events over the last several years have demonstrated that America's aging electrical infrastructure is increasingly vulnerable to outages and other disruptions. Intense storms, such as Superstorm Sandy (2012) and Hurricane Irene (2011), debilitated sections of the eastern seaboard and left many communities without power for extended periods of time. The northeast grid, and those who depend on it, have been forced to seek new ways to avoid prolonged outages.

In addition to the overall physical damage caused by these storms, many communities, public services and companies are harmed by the loss of electrical power. Emergency services are harder to perform when the grid is down, including the rescue of the injured, or those trapped in high-rise buildings. Communications, including mobile phone service, is compromised. And businesses ranging from the local grocery to large-scale corporations lose money every minute they are without power. For this reason, back-up generators, typically diesel systems, are utilized to supplant lost grid power. However, this century-old technology suffers from issues of reliability, noxious emissions, and high noise levels.

Fuel cell technology is proving to be a viable and effective solution to grid reliability issues. Fuel cells generate electricity through an electrochemical reaction, not combustion, and when using hydrogen fuel, produce no harmful emissions. Because they contain few moving parts, they are both reliable and quiet. The Fuel Cell Industry offers a variety of highly resilient products using a number of different fueling models including those able to be fueled by packaged and bulk methanol and hydrogen. Some may be fueled through America's vast underground natural gas lines, which are far less likely to be damaged by weather events than today's electric utility grid.

Many utility companies are integrating large-scale fuel cell systems, up to tens of megawatts (MWs) in size, into the local power grid to generate ongoing and reliable power. Data centers are choosing fuel cells to ensure continuity of power for their business operations. Smaller back-up power units provide seamless power for cell phone towers and critical telecommunications equipment. Retailers, universities and other institutions are using fuel cells onsite, and in some communities, fuel cells provide power to emergency shelters and other essential services.

From the Caribbean to New England, fuel cell installations have proven to be effective during and after severe weather occurrences. Today, several northeastern states offer programs to encourage the adoption of resilient fuel cell technology in both primary and back-up power capacities; further expansion of state-level programs would encourage wider deployment of this rugged and reliable technology. Fuel cells already power critical facilities - hospitals, police stations, telecommunications, wastewater treatment plants and, soon, microgrids - and can play an even larger role in helping the Northeast successfully ride out the next big storm. A combination of community and industry efforts must be united with the effective state policies.

As the U.S. Department of Energy noted in its December 2014 report, *State of the States: Fuel Cells in America 2014:* the common denominators for growing fuel cell industry success includes:

- Collaboration and coordination among the industry's players (business, government, and academia);
- Supportive government policies, created by the legislature and/or governor, which encourage the development and deployment of fuel cells;

- Incentives for fuel cell-related businesses to move to the state and to grow and succeed;
- Financial support (grants, loans, tax incentives) for end users to encourage fuel cell demonstrations and deployment; and
- Availability of a fueling infrastructure. [1]

The Fuel Cell and Hydrogen Energy Association applauds state efforts to enhance resiliency using fuel cells and encourages the expansion of programs and funding to assist vulnerable states in the reduction of the widespread impact of grid outages.

[1] DOE, *State of the States: Fuel Cells in America 2014*, p. 7.

Introduction

Over the past several years, the northeastern electrical grid has been impacted by power outages and blackouts more frequently than any other region in the United States.[2] In some of these incidents, outages were caused by an aging transmission system infrastructure that failed during storms and other severe weather incidents, exposing the lack of resiliency of the outdated power grid.

The problems with the northeast grid stem from conditions that are echoed throughout the American electrical infrastructure. The Associated Press reports that, "every day, 500,000 Americans lose power for an hour or more. Outages cost the economy $80 billion to $188 billion per year."[3] In the northeast, the average downtime is 214 minutes per end-user annually, compared to the four minutes of downtime per end-user annually in Japan.[4]

The American power grid is incredibly extensive and interconnected, which inherently increases the threat of outages caused by downed power lines. In the event of a loss of power, many industries utilize diesel back-up generators to provide critical power until grid power is restored. However, fuel to power these generators can run out during longer outages, or the diesel generators malfunction, rendering them useless. These limitations, and more, were exposed in the aftermath of Superstorm Sandy.

Superstorm Sandy caused outages for over 8.1 million people from Virginia to Maine, and as far west as Michigan.[3] This storm proved that the northeast power grid was neither reliable nor resilient enough to stand up to extreme weather. With no power at home, many people found refuge in their cars, using precious fuel to generate heat and charge electronics. Many news outlets reported the struggles of those affected by the storm when trying to buy gasoline. Many people waited in line for gasoline not just for their cars, but also for portable generators. In some cases, lines for fuel stretched miles and many gas stations ran out of fuel before all the customers were serviced, or lacked electricity to power the pumps.

Diesel back-up generators also proved unreliable after the Derecho storms knocked out power across the Washington, D.C. area in 2012.[5] Backup diesel generators failed at several Verizon facilities causing nearly 2.3 million people to lose access to 911 services for four days.[6]

These storms are just a few examples that underscore the need for resilient power generation in the northeastern United States. The Electric Power Research Institute (EPRI) describes grid resiliency as various means of "hardening" the grid to survive and return to normal operating conditions following severe weather events.[7] From high efficiency and reliability to fuel flexibility and low emissions, fuel cells provide distinct advantages over incumbent electrical generation technologies. Fuel cells answer the question of how to sustain the northeastern grid after a severe storm.

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[2] NPR. Superstorm Shines Light on Grid Vulnerabilities. 30 October, 2012. Web.
[3] Curtin, Sandra, Jennifer Gangi, and Ryan Skukowski. The Business Case for Fuel Cells 2012. Fuelcells.org. Web.
[4] Neuman, Scott. " Superstorm Shines A Light On Power Grid Vulnerabilities" NPR. October 30, 2012. Web.
[5] Flaherty, Mary Plat. "Verizon details errors in derecho, calls response to 911 outages 'insufficient'." The Washington Post. 13 Aug. 2012. Web.
[6] When the Grid Fails. April 2013. Fuel Cells 2000, Fuelcells.org. Web.
[7] "Enhancing Distribution Resiliency: Opportunities for Applying Innovative Technologies." Electric Power Research Institute. January 2013.

The Fuel Cell Advantage

A fuel cell generates electricity through an electrochemical reaction instead of traditional combustion. When fueled by hydrogen fuel cells produce no harmful emissions, only water vapor. Since there are few moving parts, fuel cells provide an unmatched reliability. They are also rugged and durable in the face of harsh weather.

The Fuel Cell Industry offers a variety of highly resilient products using a number of different fueling models, including methanol, fossil fuels, and hydrogen derived from both renewable resources and America's abundant natural gas supplies. The nation's 305,000 mile natural gas pipeline system[8] provides a tremendous opportunity to build out new distributed (on-site) power generation, at or near the point of use. Many large fuel cell systems, like those used to power police stations, grocery stores and hospitals, utilize America's underground natural gas pipeline network, increasing their resiliency, and utilizing natural gas in fuel cells also provides considerable reduction in toxic and particulate pollution over combustion-based generation using fossil fuel.[9] Smaller fuel cell systems, like those used to power telecommunications, utility communications and traffic signaling, use hydrogen and/or methanol as fuel, which diversifies the requirement for fuel during an ongoing outage event.

Fuel cells perform at an average efficiency of 50% to 60% compared to the typical 30% efficiency of the U.S. electrical grid.[10] When fuel cells are configured into a combined heat and power (CHP) system - where waste heat is captured and utilized for heating or cooling buildings, or liquids such as water - fuel cells can achieve efficiencies of up to 90%, making a CHP fuel cell one of the most efficient and environmentally-friendly energy technologies available.

The technology's fuel flexibility also permits configurations for running on renewable fuels, such as hydrogen produced via wind or solar-powered electrolysis, or on the biogas produced as a byproduct of water treatment facilities and landfills.

Fuel cells in distributed generation[11] (DG) applications have proven to be resilient in the face of severe weather, such as the emergency response to Superstorm Sandy in 2012. While cell towers running on diesel backup generators failed because of a lack of access to fuel, a fuel cell manufacturer with 60 fuel cells operating throughout the northeast reported that their fuel cells successfully provided continuous power to telecommunication towers throughout the storm.[12] Fuel cell installations like these supply critical power to remote areas that traditional supplies cannot easily access, all while operating reliably, cleanly, and with little noise and vibration. [13]

Fuel cells alleviate several of the main problems associated with traditional generators. Diesel generators require regular maintenance because they contain many moving parts and during operation produce toxic and smog-generating emissions. Fuel cells have few moving parts and are considered a

[8] "About U.S. Natural Gas Pipelines." EIA. U.S. Energy Information Administration, 2007. Web.
[9] Diesel exhaust "…is a complex mixture of thousands of gases and fine particles (commonly known as soot) that contains more than 40 toxic air contaminants. These include many known or suspected cancer-causing substances, such as benzene, arsenic and formaldehyde. It also contains other harmful pollutants, including nitrogen oxides (a component of urban smog)." California Office of Environmental Health Hazard Assessment. Air Toxicology and Epidemiology. Health Effects of Diesel Exhaust. Factsheet. Web.
[10] Benefits of Fuel Cell Technology. Fuel Cells 2000. October 2014. Web.
[11] What is Distributed Generation? Bloom Energy. Web.
[12] Satyapal, Sunita. "Calling All Fuel Cells." Department of Energy, 7 Dec. 2012. Web.
[13] U.S. Department of Energy. Early Markets for Fuel Cell Backup Power. (Oct. 2014).

low-to-zero emission technology. Fuel cells operating on methanol and other fossil fuels do not produce particulate matter and have greatly reduced toxic and smog-generating emissions, while a hydrogen fuel cell's only by-products are water vapor and heat. Additionally, fuel cells operate quietly compared to noisy diesel generators, allowing the technology to be sited indoors or outdoors in residential or urban areas that might have noise restrictions in place. Many diesel generators require large room for fuel storage, while large-scale fuel cells can hook up directly to natural gas pipelines, eliminating the need for onsite fuel storage.

Fuel cells can be critical in helping to maintain a business's' bottom line. During a power outage, a company can lose between $41,000 to $6,480,000 in revenue per hour.[10] Today telecommunication networks, data centers and many large Fortune 500 companies choose fuel cells as a reliable source of primary or supplemental power, operating them parallel to the grid, or using them to replace grid power altogether. Some of the largest consumers of fuel cells today include:

- Apple (10.3 MW at two locations)[14]
- AT&T (25 MW at 36 locations; and 431 fuel cells at 180 cellular tower sites)[15]
- Delmarva Power (30 MW at two locations)[16]
- Dominion (14.9 MW)[17]
- eBay (6.5 MW at two locations)[18]
- Sprint (500 fuel cells for cellular towers)[19]
- Verizon (10.4 MW at 13 sites)[20]
- Walmart (more than 11 MW at 35 retail sites)[21]

Many companies who put a high value on reliability have paid a premium for the reliability that fuel cells provide. However, fuel cells should not be seen as the "more expensive" option. Federal tax credits bring the capital cost of fuel cells to near parity for many models. The savings seen in operational budgets due to the lower maintenance requirements of fuel cells is where the real savings is.

There are already dozens of stationary and backup power fuel cells operating in the northeast states and hundreds operating throughout the United States. As we continue to face severe weather events, the wider use of fuel cells for utility-scale and distributed generation applications will help to ensure the provision of reliable and resilient power for end users.

See the Appendix (p.15) for case studies about several leading fuel cell producers and their customers.

State Fuel Cell Policies are Key to Resiliency Efforts

Fuel cell deployment requires a combination of efforts by both the private and public sectors. Fuel cell producers have developed highly reliable products, many of which are affordable now. Manufacturers continue to work to achieve even better price points for customers. Potential fuel cell customers must

[14] Business Case for Fuel Cells 2013. Fuel Cells 2000.
[15] Business Case for Fuel Cells 2014. Fuel Cells 2000.
[16] Ibid.
[17] Ibid.
[18] Ibid.
[19] DOE Helps Sprint Put Fuel Cells on Cell Towers. January 29, 2014. Web.
[20] Ibid.
[21] Ibid.

have information about fuel cells and may require assistance in purchasing and installing fuel cell systems, including state and local permits and tax policies. Fuel cell manufacturers continue to work hard to make adoption of fuel cells simple for customers, with some companies offering all inclusive packages designed to take the pain out of adoption from first contact through ongoing operation.[22] Public policy at all levels of government must be supportive of fuel cell installation, and avoid imposing regulatory or other barriers to their use.

As the case studies in the Appendix confirm, fuel cell manufacturers and their commercial customers are doing their share to develop and effectively utilize fuel cell systems.

Northeastern states are also advancing fuel cell use. According to the U.S. Department of Energy's (DOE) December 2014 report, *State of the States: Fuel Cells in America 2014*, [23] Connecticut and New York are among the top-five states for fuel cells, and Massachusetts, New Jersey, Pennsylvania and Rhode Island are all making great strides as well.

Northeastern states have recognized the reliability issues associated with traditional grid generation, and many of those states are taking steps to address these problems by encouraging clean and reliable energy technologies. Many fuel cell installations are supported by federal and state policies and regulations that promote alternative solutions to traditional grid power and diesel backup power generation. States like New Jersey, New York, and Connecticut have implemented resiliency-based incentives to increase adoption of technologies such as fuel cells.

The DOE report explains that successful fuel cell states typically feature "…a combination of players" working together to develop the state's expertise in fuel cells and hydrogen:

- State economic development agencies that believe the state's strengths in fuel cell and hydrogen technologies will lead to innovative research, patents and products. The goal is to develop an expanding and vibrant industry that will bring economic benefits to the state, such as business attraction and growth, and out-of-state investment.
- State energy and environmental agencies looking to reduce greenhouse gas and other polluting emissions (often to facilitate compliance with state renewable portfolio standards) and to improve grid energy security. These agencies are often home to funding programs that help to facilitate demonstrations and early market deployments of new and innovate energy technologies, such as fuel cells and hydrogen fueling.
- State lawmakers, for the same reasons: to promote low-emission energy technologies and reduce the impact of storms and other interruptions to the energy grid. Lawmakers can set state emission reduction goals, create and fund renewable energy and business development programs, and devise tax incentives for fuel cell and hydrogen technologies.
- State governors, who set the stage for state efforts, like the governors from eight states who agreed to a new initiative to put 3.3 million zero-emission vehicles (including fuel cells) on their roadways by 2025.
- Researchers at state universities and laboratories, as well as in nascent and established businesses, that are driving fuel cell and hydrogen innovation and product development.
- Businesses that are evolving and growing, often with support from state agencies, as they move toward serial production of their fuel cell and hydrogen technology products, or toward further

[22] GenKey. Plug Power. Web.
[23] *State of the States: Fuel Cells in America 2014.* Department of Energy. December 2014. Web.

growth within the regional, state, national or international fuel cell industry. These include not only fuel cell manufacturers, but also equipment and material suppliers, installers, and developers of fueling infrastructure.

- Coalitions or partnerships comprised of government, industry, and academia, working together on education and outreach, developing vision plans and roadmaps, and representing and promoting the state's fuel cell industry.
- Willing customers seeking to achieve sustainability goals by purchasing renewable energy, reducing emissions while ensuring reliable power. Many Fortune 500 companies such as Walmart, AT&T, Apple, Sprint, Procter & Gamble and others are deploying fuel cells at facilities around the country and helping to sway other stakeholders to follow suit.

There are several policy tools that have been implemented to help support fuel cells. Interconnection standards, net metering, and renewable portfolio standards are examples. (See below)

Net Metering and Interconnection Standards - Crucial for Fuel Cell Success

Two primary policies that enable fuel cells and other clean energy technologies to effectively enter service are net metering and interconnection standards.

- Net metering allows for the flow of electricity both to and from the customer—typically through a bi-directional meter. When a customer's electricity generation exceeds the customer's use, electricity flows to the grid.

- Interconnection standards specify the technical and procedural processes by which a customer connects an electricity-generating system to the grid. Such standards include contractual terms that system owners and utilities must abide by.

Renewable Portfolio Standards – Encouraging Clean Power Generation

To facilitate clean energy use, many northeastern states have created Renewable Portfolio Standards (RPS) that requires a designated percentage of electricity to be generated through processes that qualify as renewable. Depending upon what each state defines as a renewable energy source, RPS standards can be met by using fuel cell technology.

However, limiting qualification to fuel cells only fed by renewably-generated fuels limits the adaptation of this technology that provide resilient, efficient and clean energy solutions. While the use of reformed hydrogen gas does lead to small amounts of CO_2 emissions, fuel cells are still vastly more efficient and less polluting than traditional power plants. In some cases, fuel cell emissions are so low they are completely exempt from air permitting requirements. [24]

Property Assessed Clean Energy (PACE) programs can be used by local governments to finance renewable energy systems or energy efficiency improvements. Local governments finance the cost of the improvements and the property owner pays back the loan over 15-20 years through an additional tax assessment on their property tax bill. The property owner receives immediate benefits from energy improvements via a reduced electric bill. The PACE assessment and lien are tied to the property, not the owner, and are transferred to a new owner upon a sale of the property.[25]

[24] Fuel Cell Benefits. Fuel Cells 2000, fuelcells.org. web.
[25] *State of the States: Fuel Cells in America 2014.* Department of Energy. December 2014. Web.

Tax incentives for the purchase and installation of the technologies, net metering, interconnection standards, and other policies are facilitating the use of alternative clean energy technologies nationwide. These policies will lead to increased resiliency through distributed generation and reduce greenhouse gas and other harmful emissions, helping states achieve their emissions targets including those set by the United States Environmental Protection Agency's (EPA) Clean Power Plan Proposed Rule which would cut carbon emissions at power plants across the country.[26]

[26] EPA Clean Power Plan Proposed Rule. U.S. Environmental Protection Agency. Carbon Pollution Standards. January 15, 2015. Web.

The Northeastern States & Fuel Cells - Strategic Planning & Practical Action

State Support Overview

The following table shows the breakdown of the northeast states' policies for Renewable Portfolio Standards (RPS), net metering, and interconnection standards as they relate to fuel cells. While it is encouraging that most states include fuel cells in some manner within these programs, the restrictions on only allowing fuel cells operating on renewable fuels prevents a larger adoption of this technology. Fuel cells provide both strong resiliency and environmental benefits, even when using non-renewable fuel sources.

State	Renewable Portfolio Standard	Net Metering	Interconnection Standards
Connecticut	*Fuel cells using both renewable and non-renewable fuels qualify as a Class I Renewable*	*All fuel cells qualify*	*All fuel cells qualify*
Maine	*Fuel cells that utilize renewable fuels qualify as a Class I Renewable*	*Fuel cells that utilize renewable fuels qualify*	*Fuel cells that utilize renewable fuels qualify*
Massachusetts	*Fuel cells that utilize renewable fuels qualify as a Class I Renewable*	*All fuel cells qualify*	*All fuel cells qualify*
New Hampshire	*Fuel cells that utilize renewable fuels qualify as a Class I Renewable*	*Fuel cell systems up to 1 MW qualify*	*No defined interconnection standards*
New Jersey	*Fuel cells that utilize renewable fuels qualify as a Class I Renewable*	*Fuel cells that utilize renewable fuels qualify*	*Fuel cells that utilize renewable fuels qualify – though varies dependent on system size and certification*
New York	*Fuel cells that utilize renewable fuels qualify as a renewable*	*Fuel cells that utilize renewable fuels qualify – Up to 10 kW for residential, 1.5 MW for non-residential*	*Fuel cells that utilize renewable fuels qualify*
Rhode Island	*Fuel cells that utilize renewable fuels qualify as a renewable*	*Fuel cells that utilize renewable fuels qualify – Up to 100% of electricity for residential use, up to 5 MW for non-residential*	*Fuel cells that utilize renewable fuels qualify*
Vermont	*Does not have an RPS – Is a carbon-neutral state*	*Fuel cells that utilize renewable fuels qualify – up to 500 kW*	*All fuel cells qualify – Separate requirements for up to 150 kW and other distributed generation systems*

**Areas highlighted in yellow distinguish programs that focus solely on fuel cells using renewable fuels, a potential obstacle to expanded fuel cell deployment*

Additional State Programs

The most effective state programs and policies promoting fuel cell adoption have been highlighted below. To make the entire Northeastern grid more reliable, it is important that states in the region share best practices and encourage wider adoption and extension of these clean energy policies.

Connecticut

Connecticut offers some of the most supportive policies and funding opportunities to encourage the use of fuel cell technologies. The state is home to the nation's largest fuel cell power park, as well as fuel cells that provide reliable power to schools, public buildings, and soon, microgrids.

In an effort to increase emergency preparedness and improve responsiveness to severe weather, the state's Department of Energy and Environmental Protection (DEEP) created a Microgrid Program,[27] which has funded several rounds of projects, including fuel cell installations,[28] to increase statewide grid resiliency. This program helps ensure power during grid outages, including critical facilities, through the use of fuel cells and other distributed generation technologies.

In addition, Connecticut's Clean Energy Finance and Investment Authority (CEFIA), the state's green bank, has supported fuel cell power generation by using $5.8 million in ratepayer funds to leverage a $125 million life-cycle investment from energy company Dominion for development of the 14.9-MW Fuel Cell Power Park in Bridgeport. The output, which is sold to Connecticut Light & Power, is adequate to power approximately 15,000 average size U.S. homes. This installation is an example of distributed power generation – placing power near the point of use, which enhances grid resiliency.

New Jersey

In the wake of Superstorm Sandy, the state announced the New Jersey Energy Resilience Bank (ERB), which finances projects for energy recovery and resiliency to better help the state mitigate power loss from severe weather. The ERB takes advantage of $200 million in funding from the Department of Housing and Urban Development's (HUD) Community Development Block Grant-Disaster Recovery funds, which helps critical facilities like wastewater treatment and hospitals install distributed generation systems separate from the grid. Under the ERB, fuel cells for distributed generation are eligible for project financing.[29] This resiliency bank is a model for all other states that are examining preparedness of their critical facilities in severe weather to follow, and would be a boon to fuel cell adoption in the region.

Of particular note is New Jersey's incentive program for fuel cell systems. Fuel cells are eligible for rebates under a two-tiered incentive structure (see table) for a range of power capacities and includes systems providing electricity only and CHP systems that capture waste heat. New Jersey also offers the Large Energy Users Program to promote self-investment in energy efficiency and CHP at the state's largest commercial and industrial facilities. Incentives up to $4 million are available for eligible projects.

[27] Microgrid Grand and Loan Pilot Program. Connecticut DEEP. August, 2012. Web.
[28] Microgrid projects in Bridgeport and Milford awarded $5 million in state funding to harden energy system. Office of the Governor. October 14, 2014. Web.
[29] New Jersey Energy Resilience Bank. NJ Economic Development Authority. 30 May, 2014. Web.

New Jersey Combined Heat and Power Fuel Cells and CHP Program					
Technology	Size (Installed Rated Capacity)	Incentive ($/Watt)	Performance Bonus ($/Watt)	% of Total Cost Cap per project	$ Cap per project
Fuel cells powered by non-renewable fuel source	*≤1 MW w/ waste heat*	*$4.00*	*$0.25*	*60%*	*$2 million*
	≤1 MW	*$3.00*			
	>1 MW w/ waste heat	*$2.00*		*45%*	*$3 million*
	>1 MW	*$1.50*			

Similar programs and rebate structures in other states could assist with fuel cell adoption across the Northeast.

New York

New York Governor Andrew Cuomo launched the New York Green Bank (NYGB), a state-sponsored bank administered by the New York State Energy Research and Development Authority (NYSERDA) that works with private industry to increase clean energy investments.[30] In the first request for proposals, NYGB is seeking participants in clean energy project financing, including fuel cells. Through the use of incentives like credit enhancement and asset loans, New York is helping driving investment through the private market in technologies like fuel cells.

New York also has a Fuel Cell Rebate and Performance Incentive Capacity Program that provides additional incentives for fuel cell installations.

Fuel Cell Rebate and Performance Incentive Capacity Program [31]		
Capacity	***Rebate***	***Additional Incentives***
Up to 25 kW	*$20,000 per year, per project site, not exceeding $50,000*	*Additional $100,000 available in capacity incentives*
Greater than 25 kW	*Up to $1,000 per kW, additional $500 per kW if the system provides for essential services, not exceeding $1 million*	*Additional $200,000 available in capacity incentives*
***For systems of any size**, performance incentives are $0.15 per net kWh.*[32]		

The idea behind these incentive structures is to provide credits to systems that provide reliable, independent capabilities from the grid and for critical infrastructure. This measure provides increased grid resiliency in the event of severe weather. This extensive program offers many options for small and large fuel cell systems to receive funding, and is another standout incentive program among the Northeastern states.

[30] NY Green Bank. NYSERDA. 18 February, 2014. Web
[31] New York Fuel Cell Rebate and Performance Incentive. Database of State Incentives for Renewables & Efficiency. North Carolina State University, 15 Sept 2014. Web
[32] Ibid.

Other Northeast States

While other northeastern states have some sort of programs or incentives for fuel cells, none (to our knowledge) have funded recent fuel cell installations in more than half a decade.

Vermont currently receives 73% of its electricity from nuclear power and 27% from other renewables. It is a unique state since it is carbon-neutral and exempt from the EPA's Clean Power Plant rule. It is also the only state in the region that does not have an RPS. Despite being carbon-neutral, Vermont could still benefit from the installation of fuel cells both in both primary and backup power applications in order to further harden locations against utility interruption events.

Maine, Massachusetts, New Hampshire and Rhode Island also encourage the adoption of fuel cells through renewable energy incentive programs, though this focus on renewable only fuels can be detrimental to larger deployment of fuel cell installations. These states should more strongly encourage the adoption of fuel cells at public and private buildings to ensure reliable and efficient electrical generation and strengthen power resiliency.

Connecticut, New Jersey and New York offer great models to follow – a variety of incentive programs, green energy banks, and frequent funding opportunity notices – providing a template for successful integration of fuel cells into the states' profile of resilient energy resources.

Conclusion

Applications of fuel cells as both distributed and grid-scale generation have demonstrated that the technology is effective, efficient, and reliable. No other technology can claim both the resiliency and efficiency of fuel cells, while still achieving significant emission reductions.

The northeast power grid is one of the most vulnerable in the country, and inaction to update and improve the power infrastructure could prove disastrous and extremely costly in the event of a future severe weather event. Fuel cells have demonstrated that the technology can and should be a practical solution to the issues facing the grid. Northeast states should continue to enact proactive legislation and funding programs to promote the growth, development, and deployment of fuel cells - for distributed generation and backup power - to ameliorate or prevent future outages.

With the growing number of fuel cell installations at Apple, eBay, Walmart, and at municipal facilities such as city halls, high schools and government complexes, customers are increasingly recognizing the importance of clean and reliable fuel cell power generation. The future of fuel cells in northeastern states depends upon collaboration between the private sector and federal, state, and local governments to make the technology more readily available to customers. Making fuel cells more available to critical sites, such as data centers, telecommunication networks, schools (which can double as emergency shelters), hospitals, government centers and first responders will significantly improve readiness and responsiveness when the grid fails.

It will take time to strengthen and improve the northeast grid, but with policies that promote the adoption of fuel cells, the Northeast can reverse the trend of poor grid resiliency and build a true 21st century electric infrastructure.

Case Studies - Fuel Cell Systems Power Through Storms

U.S. fuel cell companies are leaders in stationary power generation. To date, these companies have contributed more than 250 MW of both large and small-scale installed fuel cell capacity across thousands of sites in the United States.[33] The research, development and deployment of fuel cells by America's leading fuel cell companies have helped fuel cell technology expand into foreign markets, and demonstrate the reliability and efficiency of fuel cells worldwide.

Ballard Power Systems

Ballard Power Systems, Inc. is a global leader in proton exchange membrane (PEM) fuel cell technology. The company offers seven different models of their fuel cell stacks, fuel cell modules and complete fuel cell systems used in many applications, such as backup power, distributed generation, material handling, and fuel cell electric buses.

Ballard's ElectraGen™ fuel cell power generation systems fueled by hydrogen or methanol, offer backup power for both 'short duration runtime' and 'extended duration runtime' requirements. In 2012, before Superstorm Sandy impacted the East Coast, it hit the Bahamas, causing blackouts and massive amounts of damage across the islands. Ballard's 5-kW ElectraGen-ME fuel cells successfully provided continuous backup power for cell towers on the islands of New Providence, Abaco, and Grand Bahama, allowing the Bahamas Telecommunications Company to maintain cellular connections, which made contact with first responders possible.[34]

Ballard's fuel cells provided power for more than 700 hours, producing over 1,200 kWh of electricity. These fuel cells were powered by a methanol-water mixture. According to the Bahamas Telecommunications Company, the deployment of these fuel cell systems prevented a loss of 50% of cellular service across the islands where outages occurred. The company also reported that out of 30 sites on the island of Abaco, the only two cell towers that that remained online through the storm were powered by ElectraGen-ME fuel cell systems.[35] The standby diesel-powered generators were unreliable and the fuel cells ran independently and continually provided power throughout this weather emergency.

Bloom Energy

Bloom Energy offers an on-site primary power solid oxide fuel cell (SOFC) system, the *Energy Server*, which provides a reliable and efficient alternative to the traditional electric power grid. Bloom's Energy Servers, available in 50 kW, 100 kW, and 200 kW sizes, have been installed across the United States to provide high-quality primary and backup power generation to a wide range of customers.

Bloom has installed 30 MWs at targeted substations in Delaware for Delmarva Power, a subsidiary of Pepco Holdings, Inc., the equivalent to almost 30,000 average-sized U.S. homes.[36] Bloom's fuel cell systems at Delmarva Power's New Castle substation continued to operate without disruption, feeding

[33] Estimate based on internal calculations
[34] When the Grid Fails. April 2013. Fuel Cells 2000, Fuelcells.org. Web.
[35] Case Study - Providing Power for Telecom Services in the Bahamas During Hurricane Sandy. Ballard Power. Sept. 2012. Web
[36] Comments on the 2013 Integrated Energy Policy Report (IEPR) Publication Number: CEC-100-2013-001-LCD.. Bloom Energy. October 29, 2013. Web.

power to the grid while Superstorm Sandy passed directly overhead.[37] Because of Bloom's fuel cell systems, Delmarva provided continuous power to more than 503,000 customers throughout Delaware and along the eastern shore of Maryland while other many parts of the electric grid remained offline.[38]

Doosan Fuel Cell America

Doosan Fuel Cell America is a subsidiary of Doosan Corporation - a Fortune Global 2000 member since 2007, with operations in 38 countries and over 40,000 employees worldwide - Doosan Fuel Cell America's PureCell® Systems offer up to 90% efficiency and more than 11-million hours of fleet operation. Doosan's PureCell System is the culmination of five decades of engineering, testing and development. Featuring 98% system uptime, it's a versatile clean energy solution that can be deployed in virtually any building environment, outside or indoors, and can produce 440 kW of continuous power and 1.7 MMBTUs of usable heat to sustain business operations in the face of natural and manmade disasters.

In October 2012, when Superstorm Sandy ravaged the East Coast of the U.S. and Canada, causing widespread economic destruction and power outages, PureCell Systems in New York and Connecticut remained in operation, running independent of the grid and providing Doosan customers with heat and electricity throughout the crisis. The fuel cells at Price Chopper in Colonie, New York, and Middletown, Connecticut, operated without the grid for five and six days, respectively. This allowed the supermarkets to keep food available, lights on, registers open, and the hot water system functioning. At Stop & Shop, in Torrington, Connecticut, the fuel cell system provided the grocery store with power, heating and cooling while the grid power was intermittent.

The University of Connecticut (UConn) at Storrs, seeking in a continuing effort to reduce its carbon footprint and build a sustainable community, is partnering its existing 400-kW PureCell® fuel cell system with a demonstration-scale 6.6-kW photovoltaic solar panel array to create a grid-independent microgrid, which will provide clean, reliable, uninterrupted power to a cluster of Depot Campus buildings during prolonged grid outages. Currently, the PureCell fuel cell system delivers baseload power, as well as heating and cooling, to critical research labs and offices. When the microgrid becomes operational, significant locations on campus will have heat and power, even during an extended power outage. This will allow UConn to provide critical services, such as warming spaces for the public with kitchens, bathrooms, outlets for recharging electronic devices, and nearby charging stations for electric vehicles. The microgrid will also provide power for staging areas for emergency and storm recovery teams, and emergency command and response centers for police, fire, and other public safety professionals.

Whether they are running on clean, abundant natural gas or bio-gas, deployed as single energy solutions or chained together for multi-megawatt energy generation, Doosan fuel cells are a practical solution for secure, reliable energy generation.

FuelCell Energy

[37] Power Through Any Storm. Bloom Energy. 2012. Web.
[38] California Energy Commission. Integrated Energy Policy Report 2013, 2013. IEPR. California Energy Commission. Web.

FuelCell Energy, Inc., based in Danbury, Connecticut, designs, manufactures, installs, operates and services large-scale stationary fuel cell power plants. FuelCell Energy offers molten carbonate fuel cell (MCFC) products that range from 300 kW to 2.8 MW and hybrid, multi-megawatt Direct FuelCell Energy Recovery Generation (DFC-ERG) systems that not only generate clean electricity, but recover energy normally lost during natural gas pipeline distribution operations. These DFC-ERG units are scalable to reach higher capacities, such as the 14.9-MW system installed at Dominion's substation in Bridgeport, Connecticut. This substation is one of the nation's largest producers and transporters of energy. [39]

The project is located on a remediated brownfield site in an industrial area of Bridgeport and generates power for nearly 15,000 average-sized U.S. homes. The plant uses only about one-and-a-half acres of land to provide 14.9-MW of base load fuel cell power. The city of Bridgeport not only receives clean, reliable, locally sourced power, but additional tax revenue from a previously vacant lot.

FuelCell Energy's multi-megawatt installations in Connecticut and around the United States are providing ultra-clean, efficient and reliable distributed generation for electric utilities, commercial and industrial companies, universities, municipalities, government entities, and showcase the potential of fuel cells to provide resilient primary power.

Plug Power

A powerhouse in hydrogen fuel cell technology, Plug Power is revolutionizing the material handling and stationary power industries with cost-effective solutions that increase reliability, lower operating costs and reduce carbon footprints. Its signature solution, GenKey, provides an all-inclusive package for customers, incorporating GenDrive or ReliOn fuel cell systems, GenFuel hydrogen and fueling infrastructure, and GenCare aftermarket service. ReliOn, a suite of highly reliable hydrogen fuel cell solutions specifically designed to meet critical customer backup, grid-supplement and off-grid power requirements, addresses markets including telecommunications, utility, government and railroad. ReliOn fuel cell solutions provide scalable, clean, cost-effective performance while offering an exceptional degree of flexibility in addressing the space constraints of customer locations, with both indoor shelter and outdoor cabinet options. With 6 MW of fuel cell product delivered to nearly 2,000 customer locations in 46 U.S. States and 36 countries, ReliOn products provide proven technology to meet critical customer needs.

Plug Power is headquartered in Latham, New York with offices in Spokane, Washington, and is a premier system integrator in the rapidly emerging PEM-based fuel cell market. Plug Power manufactures ReliOn systems at the Spokane center and GenFuel dispensers at the Latham facility.

During Hurricane Irene in 2011, ReliOn fuel cell emergency backup power systems played a role in keeping telecommunication towers operational.

Hurricane Irene struck the East Coast causing over $7.3 billion worth of damage and killing 45 people.[40] Power outages left residents and businesses without power and disabled telecommunication towers for hours. Despite the damage, ReliOn reported that all 45 of Sprint's fuel cell-equipped telecommunication

[39] List of FuelCell Energy Products. FuelCell Energy, 2013. Web.
[40] "Extreme Weather 2011: Hurricane Irene." National Oceanic and Atmospheric Administration. U.S. Department of Commerce, Web.

towers that were affected by grid outages were able to provide emergency power to the towers for a cumulative time of 725 hours. The average duration of outages per site was 16 hours, with the maximum single outage duration being 50 hours. The fuel cells were powered by bulk hydrogen provided by Air Products.[41]

Additional Fuel Cell Customers - Hospitals, Stores, Data Centers & Businesses

Fuel cell backup power goes beyond telecommunications towers. Hospitals, grocery stores, data centers, and other buildings that require large amounts of power to function are beginning to add fuel cells for backup and primary power purposes to eliminate energy dependence on the grid.

After Superstorm Sandy caused widespread evacuations and emergency procedures at northeastern hospitals, many are adopting fuel cell technology as their backup power generation systems, including Stamford and Waterbury Hospitals in Connecticut, with 4.8 MW and 2.4 MW systems respectively. These hospital fuel cell units were installed by FuelCell Energy.[42]

Large shopping centers and grocery stores are also adopting fuel cell technology to preserve perishables during outages. In an effort to be more environmentally friendly, Walmart is working towards a goal of utilizing 100% renewable energy at its stores and distribution centers. Bloom Energy fuel cells are already installed at 35 Walmart and Sam's Club locations in California and Connecticut. These fuel cells produce a total of 65 million kWh of electricity each year, providing the stores with 40-70% of their annual energy needs.[49]

Due to the large amounts of revenue lost in the event of an outage, data centers are investing in reliable and efficient backup fuel cell generation systems. Apple's new iCloud data center in Maiden, North Carolina, receives 10 MW of electricity from 24 Bloom Energy fuel cells. Additionally, the fuel powering the fuel cells is harvested from biogas at a landfill three miles away.[49] Bloom's fuel cells also are the primary energy source for eBay's data center in Utah, and Bloom has installed fuel cells for Kaiser Permanente, Google, Williams-Sonoma, AT&T (Bloom's largest non-utility customer) and many others.[43]

The Bottom Line - Fuel Cells Are Making a Difference Today

The rapid adoption of fuel cell systems by major corporations, hospitals, telecommunication providers, and other businesses demonstrate growing awareness that fuel cells are among the most reliable, resilient, and efficient electrical power sources during blackouts and outages. A proven track record and a growing list of customers confirms that the right combination of private sector innovation and supportive public policies can have a dramatic positive impact on people and communities in the northeast, and throughout the U.S.

[41] [41] When the Grid Fails. Fuel Cells 2000, Fuelcells.org. April 2013. Web.
[42] When the Grid Fails. Fuel Cells 2000, Fuelcells.org. April 2013. Web.
[43] Nicholson, Rick. "How Cheap Gas, Weather & Fuel Cells are Driving the Consumerization of Energy." GIGAOM. 6 Jan. 2013. Web.