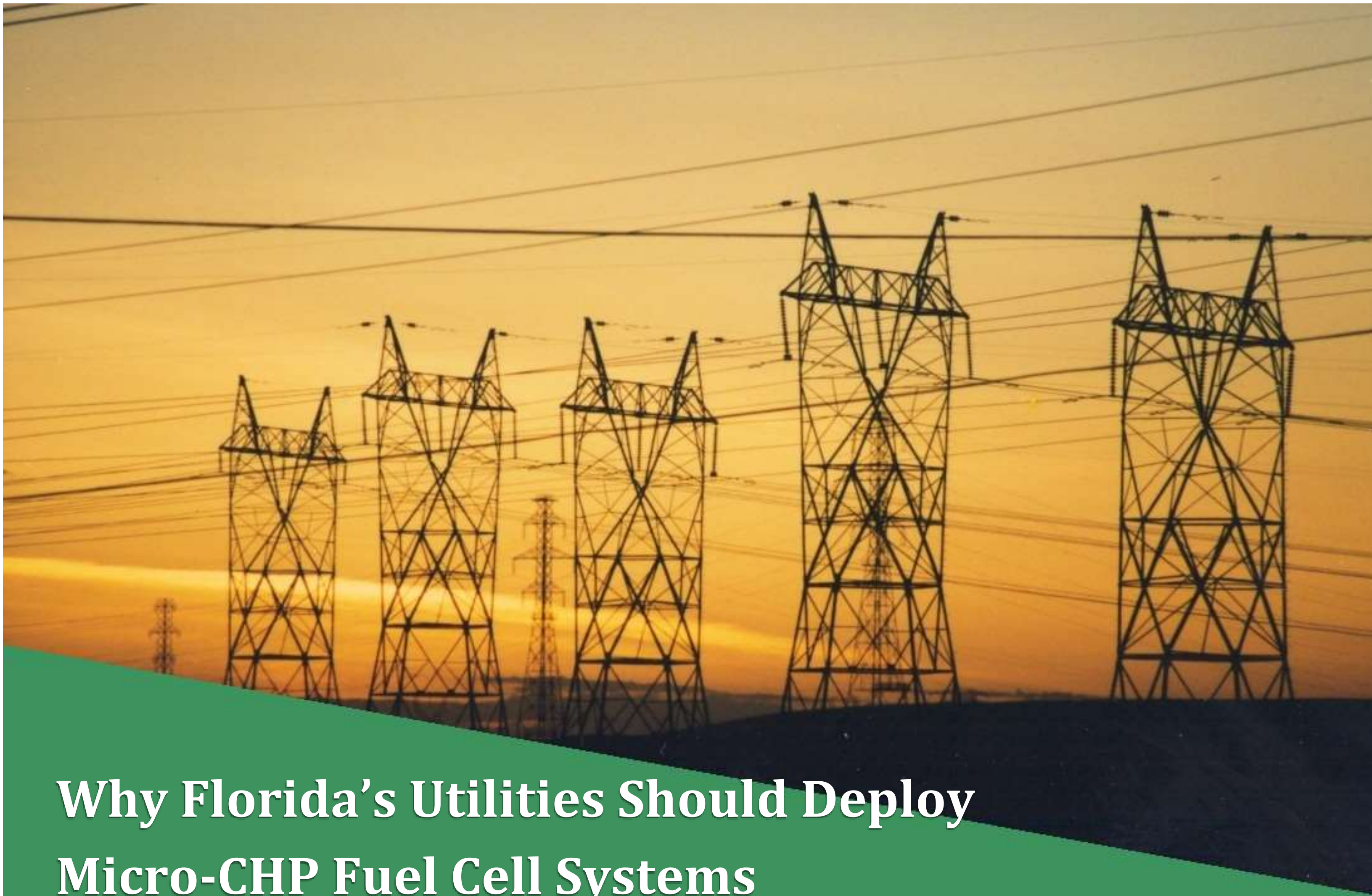


Why Florida's Utilities Should Deploy Micro-CHP Fuel Cell Systems

August 2014

Bing Energy

Introduction

Florida has the second largest residential consumption of electricity in the U.S.[1] In a 2009 survey conducted by the U.S. Energy Information Agency (EIA), electricity accounted for 90% of energy consumed by Florida households with annual expenditures exceeding the U.S. average by 40%. However, Florida was also among the states with the lowest site energy consumption.[2] This can be attributed to Florida's climate and its large number of residents. With strong demand for air conditioning throughout the year and less need for appliances such as furnaces that would consume energy on site, Florida households rely heavily on the power grid to satisfy its demand for electricity year round. This places great pressure on Florida utilities to ensure reliable electric service particularly during peak demands, requiring utilities to invest in maintaining sufficient generation, transmission and distribution of power.

With such a heavy reliance on the power grid, it is no surprise that Florida also has one of the highest carbon dioxide (CO_2) emissions from fossil fuel combustion. Florida's electric power sector was estimated in 2012 to have generated 105.83 million metric tons of CO_2.[3] In June 2014, the U.S. Environmental Protection Agency (EPA) proposed a Clean Power Plan to reduce nationwide CO_2 emissions by 30% over a period of 16 years. For Florida's part, the EPA proposes a 38.3% reduction in CO_2 emissions to help meet this national goal; this means reducing an estimated emission rate of 1,200 lb/MWh to 740 lb/MWh by 2030.[4]

These challenges present Florida utilities with an opportunity to explore new energy efficient technologies. Ideally, this new technology would accomplish the following:

- Reduce the generation levels at peak periods of electricity use;
- Supplement the intermittent electricity produced by solar and wind; and
- Emitt less CO_2 by using fossil fuels more efficiently.

This paper explores the potential of deploying residential combined heat and power fuel cell systems by utilities as a way to meet these conditions. Also known as micro-CHP fuel cell systems

[1] "Table 5.4.B. Retail Sales of Electricity to Ultimate Customers by End-Use Sector, by State, Year-to-Date through May 2014 and 2013 (Million Kilowatthours)," U.S. Energy Information Agency; available at *http://www.eia.gov/electricity/data.cfm#sales*

[2] Household Energy Use in Florida, 2009 Residential Energy Consumption Survey, U.S. Energy Information Agency; available at *http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/fl.pdf*

[3] State CO2 Emissions from Fossil Fuel Combustion, 1990-2012, U.S. Environmental Protection Agency; available at *http://epa.gov/statelocalclimate/documents/pdf/CO2FFC_2012.pdf*

[4] Interactive Clean Energy Plan Maps for State and Power Plants, U.S. Environmental Protection Agency; available at *http://cleanpowerplanmaps.epa.gov/CleanPowerPlan/*

these units produce hot water heating and electricity from a single fuel source such as natural gas, effectively maximizing the amount of useful energy generated. By generating between 5 to 50kW of electricity, they are able to supplement grid electricity in single or multi-family homes and small commercial sites.

In deploying residential micro-CHP fuel cell systems on a large scale, utilities could distribute electricity generation and reduce the load on its power lines. Utilities would also reap substantial long term savings from a decrease in peak power generation.

Distributed generation of energy will greatly improve Florida's energy efficiency. This paper will discuss the following points on why Florida utilities are best positioned to invest and implement this technology:

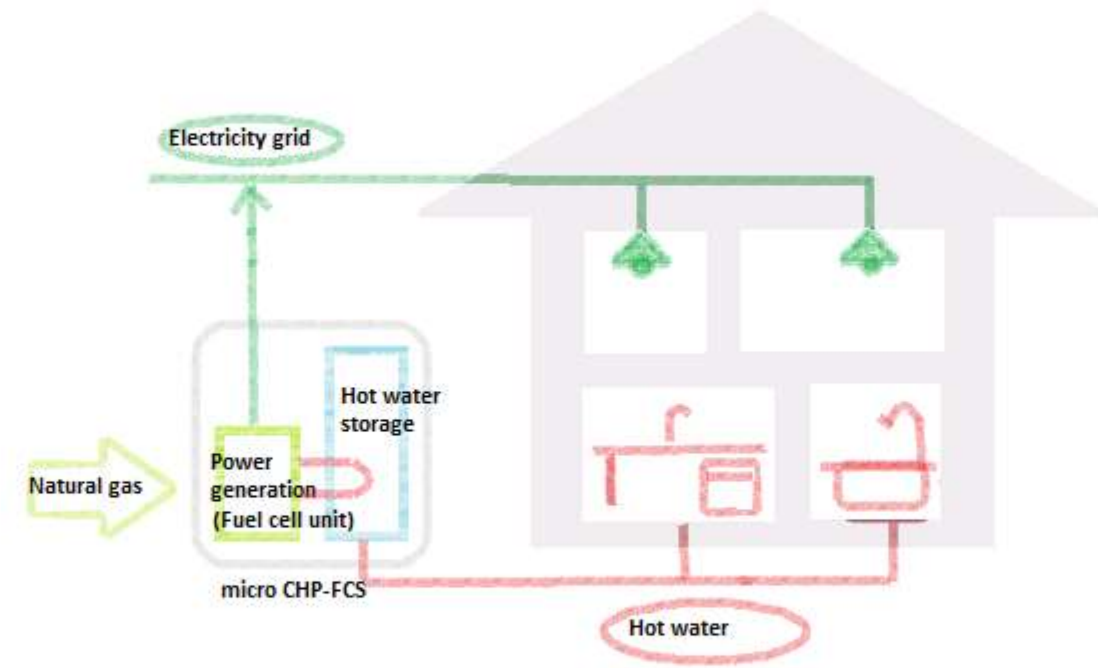
- Strategically deploy micro-CHP-FCS in areas where the grid is most constrained;
- Place micro-CHP-FCS in areas most vulnerable to power outages caused by hurricanes;
- Make investments in infrastructure that have longer payback periods;
- Leverage buying power to lower the cost of micro-CHP-FCS;
- Tailor output power of micro-CHP-FCS to match the needs of the grid;
- Enable the smart grid to use micro-CHP-FCS effectively at peak periods; and
- Work with manufacturers to design and implement the system as seen in Japan and the EU.

This paper will also examine concerns which would impede the adoption of this technology and what state policy makers could do to encourage investment in this technology.

Combined-Heat-and-Power (CHP) is a proven technology

Similar to a power plant, CHP generates electricity and thermal energy. However, unlike a power plant, CHP systems and micro-CHP systems are placed close to where the energy will be consumed. This allows the thermal energy produced to actually be used for heating and hot water. By using both the electrical and thermal energies produced, CHP energy efficiency can exceed 70% whereas separate electricity generation at centralized locations averages about 34% in the U.S. Currently, CHP systems have been used in the industrial sector for such industries as petroleum refining and paper as well as large commercial settings such as hospitals and college campuses. In 2011, CHP systems accounted for 7% of the annual US capacity.[5]

Fuel Cells have Advantages over Conventional Systems



Micro-CHP fuel cell systems are residential scale cogeneration systems. Similar to industrial and large commercial CHP systems, they produce electricity and heat for use from a single fuel source, such as natural gas. The advantage of a fuel cell system over a conventional combustion system is the reduction in CO_2 emissions and an improvement in efficiency. For micro-CHP fuel cell systems, the fuel (e.g., hydrogen, natural gas, or methanol) directly produces electricity when it is electrochemically reacted with an oxidizer (e.g., air or oxygen). The thermal energy produced during the reaction can then be used to heat water. For a micro-CHP that relies on combustion, the fuel must first be used to drive an engine; the mechanical energy produced by the engine is then used to produce electricity, which decreases the overall efficiency.

Micro-CHP fuel cell systems are also much quieter than conventional systems. Unlike an internal combustion engine, a fuel cell's moving parts consist of water pumps and air circulation fans. The

[5] "Combined Heat and Power Technology Fills an Important Energy Niche," U.S. Energy Information Agency, 4 October 2012; available at *http://www.eia.gov/todayinenergy/detail.cfm?id=8250*

fuel cell unit sold by Panasonic in Japan lists its noise level at 38dB (a normal conversation's noise level is 60dB).[6]

Micro-CHP Fuel Cell Systems are in Use Overseas

Success of ENE-FARM in Japan

In 2011, Japan experienced the greatest power system crisis since World War II. The damage caused by the Great Tohuoku Earthquake not only resulted in the devastating radiation leakage incident at Fukushima but also greatly reduced the country's electricity supply. This prompted the government to request households to reduce their demand on the centralized power grid.[7]

Coincidently, since 2009 the Japanese Government has supported the commercialization of micro-CHP fuel cell systems known as ENE-FARM for use in private homes. The systems developed by different manufacturers such as Toshiba, Panasonic, and Enoes (JX Nippon Oil and Energy) are all sold under the brand ENE-FARM. The Japanese Government along with local governments offered individual subsidies to help offset capital costs and to encourage sales. The earthquake and tsunami in 2011 pushed individuals to diversify their energy sources and the popularity of the ENE-FARM units grew. The strength of the sales has prompted the Government on several occasions to reallocate additional funds to the subsidies to maintain momentum. As of 2013, Panasonic alone has shipped out approximately 30,000 units.

ENE-FARM units run on hydrogen gas derived at the point of use from the city gas supply. It has combined electric and thermal efficiencies ranging from 80 to 95% depending on the model. Since its commercial debut, manufacturers and city utilities have worked together to improve durability and efficiency as well as reduce cost and occupied floor space. The 2013 model offered by Tokyo Gas was jointly released with Panasonic and boasts a 49% reduction in occupied floor space, a 3% improvement in efficiency, and 20% decrease in cost.[8]

Start of ene.field in Europe

Japan's successful deployment of residential micro-CHP fuel cell systems has created interest and excitement around the world. It has encouraged the European Union to set up its own field trials for residential micro-CHP fuel cell systems under project name ene.field in 2012. The project has

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[6] Panasonic Household Fuel Cell, Panasonic Co.; available at *http://panasonic.co.jp/ap/FC/en_doc03_00.html*

[7] "The Lessons of the Great Tohoku Earthquake and Its Effects on Japan's Economy (Part 6)," Fujitsu Research Institute, 10 January 2012; available at *http://jp.fujitsu.com/group/fri/en/column/message/2012/2012-01-10.html*

[8] Panasonic Household Fuel Cell, Panasonic Co.; available at *http://panasonic.co.jp/ap/FC/en_doc03_00.html*

participation from 12 member states and brings together nine mature European fuel cell micro-CHP manufacturers and four European utilities as full partners. As of June 2014, the first two of a planned 1,000 residential fuel cell based micro-CHP were installed in residential homes.[9]

Florida utilities stand to benefit from micro-CHP fuel cell systems

Reduce generation levels at peak electricity usage

Florida utilities must keep enough capacity on hand to match electricity demand at peak periods or under emergency situations. Peak power, typically generated by more expensive gas turbines or small scale generators, is produced on top of baseload power. This increases the load that must be transmitted and distributed from the power plants to individual customers.

As the load on these lines increase, energy is lost on the lines as heat. A study published in 2011 by the Regional Assistance Project (RAP) showed an average line loss of 7%, but more alarming was the calculated marginal line loss of 20% at peak periods.[10] Peak power generators need to produce more electricity to compensate for this line loss, further increasing the cost of one kWh generated at peak periods.

By placing micro-CHP fuel cell systems at individual customer locations, peak power could be generated at the point of consumption, and the loss due to transmission and distribution could be eliminated. Distributed generation would benefit service areas as a whole by saving energy and peak capacity. In doing so, utilities stand to reduce their operating costs.

Smoothing out solar and wind power

One disadvantage of using renewable resources like solar and wind systems is their varying electrical output. This variability can result in shortages or surpluses of electricity.

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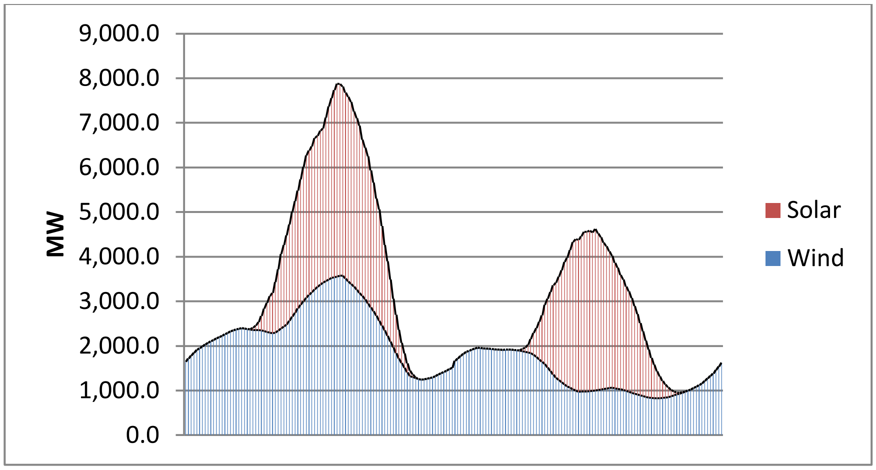
[9] PRESS RELEASE 6 - The ene.field project successfully installs its two first micro fuel cell-based combined heat and power units, ene.field, June 2014; available at *http://enefield.eu/news/press-releases/press-release-6-the-ene-field-project-successfully-installs-its-two-first-micro-fuel-cell-based-combined-heat-and-power-units/*

[10] "Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserve Requirements," Regulatory Assistance Project, August 2011; available at *www.raponline.org/document/download/id/4537*



Graph 1. Actual Power Generation from Wind and Solar in a 48 hour period (August 12, 2014 to August 13, 2014) at 50Hertz Transmission GmbH in Germany.[11]

As more focus is placed on renewable energies, these fluctuations must be addressed. As experienced by Germany in its push toward renewable energies after the 2011 Fukushima nuclear disaster, even a millisecond lag in the electrical grid can cause thousands of dollars in damages to the private sector.[12] Micro-CHP-FCS could be used to supplement these fluctuations in electrical output. Low temperature fuel cell systems, as proposed, are well suited to cycling on and off, which allows for load following.

Emit less CO_2 by using the fuel source more efficiently

Growing concern about greenhouse gas (GHG) emissions and its potential effect on our environment has intensified interest in energy efficient technologies to help address this issue. CO_2 emissions are the largest contributor to GHG emissions, and Florida utilities have made great strides over the years in its reduction. Average CO_2 emissions were 1,835 lb/MWh in 2000 and early efforts by Florida utilities reduced emissions by 34.6% over a 12-year period. Plant modernization, nuclear power, repowering, and implementation of DSM programs all contributed to the CO_2 emissions reduction.[13]

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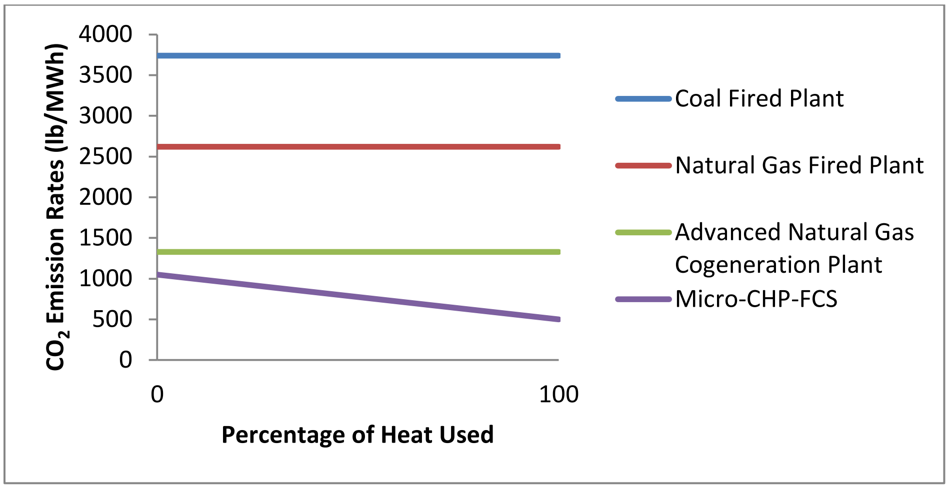
[11] European Energy Exchange (EEX)—Transparency in Energy Markets

[12] "Energy Revolution Hiccups: Grid Instability Has Industry Scrambling for Solutions," Spiegel International, August 16, 2012; available at *http://www.spiegel.de/international/germany/instability-in-power-grid-comes-at-high-cost-for-german-industry-a-850419.html*

[13] Internal Affairs Agenda, State of Florida Public Service Commission, December 4, 2013; available at *http://www.floridapsc.com/agendas/internalaffairs/iapdfs/IA-12-04-13.pdf*

While natural gas powered micro-CHP fuel cell systems still rely on an external fossil fuel source, these systems operate at lower total CO_2 emission rates because both the electricity and heat generated are used. Graph 2 compares micro-CHP fuel cell systems to a conventional coal fired plant, an average natural gas fired plant, and an advanced natural gas cogeneration plant. The CO_2 emission rate for a micro-CHP fuel cell system is already one half of an average natural gas fired plant but the CO_2 emission rate can be reduced by another 50% once the heat is used for water and/or space heating.



Graph 2: Comparison of CO_2 emission rates of micro-CHP-FCS to power plants driven by fossil fuel combustion. CO_2 emission rates decrease as more heat produced by micro-CHP-FCS units is used.[14, 15]

Reliability

Since the devastating hurricanes in 2004 and 2005, Florida utilities have spent billions on strengthening their systems against winds and storms so that power may be restored quickly after an outage.[16] Natural gas powered micro-CHP fuel cell systems are less vulnerable to power outages caused by storms and hurricanes. Since natural gas lines are buried underground, they are less susceptible to service disruption. Micro-CHP fuel cell systems could be relied on to provide partial power to homes during outages.

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[14] "Business Case for a Micro-Combined Heat and Power Fuel-Cell System in Commercial Applications," The Pacific Northwest National Laboratory, October 2013; data from the original graph was converted from g/kWh to lb/MWh; available at *http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22831.pdf*

[15] "The Green Edge of Fuel Cells," ClearEdge Power, April 2014; available at *http://www.clearedgepower.com/downloads/files/whitepapers/Green_Edge_of_Fuel_Cells.pdf*

[16] "The Legacy of Florida's Year of 4 Hurricanes," Orlando Sentinel, August 12, 2014

Florida utilities should drive implementation…

Florida utilities are best positioned to own and install micro-CHP fuel cell systems at individual customer locations. Utilities are most familiar with their service areas and are able to know where vulnerabilities to their grids lie. Utilities would be able to strategically place micro-CHP fuel cell systems to lessen the load on their systems. It would increase on-site fuel consumption at customer locations and improve system-wide efficiency of heat and electricity production. Their familiarity with their respective service areas would also allow Florida utilities to first address areas most susceptible to power outages due to storms and hurricanes and then proceed to evaluate implementation in other service areas.

Florida utilities are also familiar with investing in improvements that will have longer payback periods. In recent years, Florida utilities like Florida Power and Light transformed their grid and business with smart grid technologies.[17] Because micro-CHP fuel cell systems are powered by natural gas and feed into the electrical grid, Florida utilities could use smart grid technologies to monitor micro-CHP fuel cell systems. They could also program micro-CHP fuel cell systems to run at peak periods and then to switch back to the electrical grid at off-peak periods.

The ENE-FARM and ene.field projects in Japan and Europe illustrated the importance of having manufacturers and utilities work together to improve the existing micro-CHP fuel cell technology. By working together with city gas companies, the Japanese micro-CHP fuel cell system manufacturers were able to make dramatic improvements in affordability, durability, and efficiency. By maintaining a close relationship with utilities, manufacturers could have a firmer grasp of specifications sought by utilities and could work toward design simplification which would improve affordability. By working with manufacturers, Florida utilities could tailor the output power of the micro-CHP-FCS to generate a set amount of power to be returned to the electrical grid to offset peak demand periods. The cost of a micro-CHP fuel cell system will also go down with high production levels. By deploying micro-CHP fuel cell systems on a large scale, Florida utilities can leverage buying power to lower cost. Contracts could also be drawn up to include maintenance and service with purchase.

[17] "Here Comes the Apps: Florida Power and Light Finished $800 M Smart Grid," Green Tech Media, May 28, 2013; available at *http://www.navigantresearch.com/wp-content/uploads/2013/01/WP-FC10T-13-Navigant-Research.pdf*

...in collaboration with State regulators

Florida's utility regulator, Florida Public Service Commission (FPSC), plays a significant role in the adoption of new energy efficient technology. By keeping micro-CHP fuel cell systems on the supply-side, energy efficiency could rapidly expand under utilities' actions. However, policy will dictate speed of adoption. FPSC has promoted and monitored supply-side energy efficient improvements before, such as the Generating Performance Incentive Factor (GPIF). This policy set targets to encourage utilities to improve the energy efficiency of their baseload generating units, effectively reducing the average amount of fuel required to generate one MWh.[18]

One issue that must be addressed is how to encourage energy efficiency if it means a reduction in demand. Of course, calculating energy savings is harder than calculating CO_2 emissions, energy generation, and consumption. FPSC will need to further explore how to quantify these savings. If line loss is reduced or load patterns are improved, how can one quantify those benefits? If the cost-effectiveness of a program is determined solely through impact to the ratepayer, then Florida utilities may not have much incentive to invest in more energy efficient technologies. Rather, it would likely be more cost effective to build more power plants. Therefore, the State should provide stronger economic incentives to improve energy efficiency. The State must also specify who owns emission reduction credits, efficiency credits, electrical output and thermal output.

Conclusion

Florida residents rely heavily on the electrical grid. Florida utilities face the challenge of supplying reliable, continuous electricity to its residents whilst facing mounting pressures from government agencies and environmental groups to cut CO_2 emissions. Micro-CHP fuel cell systems deployed on a large scale can help to address this challenge. By deploying micro-CHP fuel cell systems on a large scale at residential locations, utilities can distribute peak power generation across an entire service area. In doing so, utilities could reduce their operating costs, reduce the load on their grid systems, and lower CO_2 emissions. Finally, state regulators can encourage utilities to achieve these goals through smart, targeted incentives.

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