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Opportunities for Stationary Fuel Cell Applications in Ohio: Public Finance and Other Strategies

Andrew R. Thomas
Cleveland State University, a.r.thomas99@csuohio.edu

Benjamin Y. Clark
Cleveland State University, b.y.clark@csuohio.edu

Allan Immonen

Cleveland State University
Maxine Goodman Levin
College of Urban Affairs

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Energy Policy Center

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Andrew R. Thomas
Benjamin Y. Clark
Allan Immonen

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2121 Euclid Avenue Cleveland, Ohio
44115
http://urban.csuohio.edu

Executive Summary

Ohio has not, heretofore, been a major player in the deployment of stationary fuel cell applications, notwithstanding its status as a leader in developing fuel cell technology. One reason for this is that in the years since fuel cells became commercially available, fuel cell power generation had struggled to be cost effective in Ohio due to a combination low electricity prices and high natural gas prices, the latter being the most common fuel for stationary fuel cell applications.

By 2015, this had changed. The Mid-Atlantic region was enjoying the lowest natural gas prices in North America as a result of regional shale development. Meanwhile, wholesale electricity prices in the PJM Interconnect regional transmission organization (Mid-Atlantic region) are among the highest in the nation. This has created therein a historically high "spark spread" -- the term used to describe the price differential between wholesale natural gas and electricity. What's more, fuel cell generation qualifies for net metering, and may be valued at retail costs. Finally, additional new value for the avoided costs of carbon and other emissions may be derived from new ultra-efficient fuel cell technologies.

As for other nascent technologies, early adoption will likely require public-private financing partnerships. There are available federal, state and local financing strategies to enable the deployment of fuel cells in Ohio. Loan programs such as the Energy Loan Fund and Qualified Energy Conservation Bonds can be used to support fuel cell demonstration with low interest loans. Property Assessed Clean Energy (PACE) bonds may also soon be available to support fuel cell deployment, depending upon pending Ohio legislation. In addition, the Public Utility Commission of Ohio has within its authority to support power purchase agreements or special arrangements for buyers to support generation that is in the interest of Ohio ratepayers (such as when it promotes economic development).

The best places to acquire natural gas for power generation on long-term, fixed prices will be at gathering points along the natural gas pipeline and processing system. Such points offer natural gas producers the most flexibility to supply natural gas long term. Most of the gathering and processing points are currently located in southeastern Ohio, however new interstate pipelines are being built across northern Ohio. This new infrastructure may provide opportunities to locate stationary fuel cells in the generation, transmission and capacity-constrained northern Ohio market.

Low gas prices may also provide opportunities for stationary fuel cell applications using low temperature fuel cells. Such fuel cells run directly on hydrogen, and heretofore, the costs of manufacturing, transporting and storing hydrogen has made the economics for such generation difficult. Low hydrogen feedstock costs, together with the ability low temperature fuel cells have to supply the lucrative peak loading market, may make such applications cost effective in the near term.

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I. Introduction

A. Background

Ohio has been actively engaged in efforts to commercialize fuel cells for more than a decade, especially since the Taft Administration made it a target for state support through the Third Frontier Initiative. At that time, the perception was that Ohio needed to prepare for the potentially disruptive economic effects of an anticipated move toward a hydrogen-based economy – an economy that would allow the United States to wean itself from dependence on coal and foreign oil. Today, in 2015, these issues continue to be relevant, and the fuel cell industry continues to be important to Ohio, even though the hydrogen economy had, in recent years, appeared to be less imminent.

However the rapid development of shale has flooded the region with what appears to be a long-term source of cheap natural gas – the least expensive feedstock to make hydrogen. The development of cheaper and more available natural gas has made the idea of a hydrogen economy more feasible. Further, Ohio now has another compelling interest in the adoption of fuel cell technology: at a time when Ohio must respond to air quality and carbon emission problems, fuel cells offer significant environmental advantages over conventional power generation.[1] Several large Ohio metropolitan areas, including Cleveland, Cincinnati, Toledo and Columbus, have been designated as "non-attainment air sheds," effectively restricting the building of traditional new power plants in and around those cities (nonattainment is not limited to just these four metro areas).[2] The low emission nature of fuel cells make the economics of such new generation more attractive in non-attainment areas, especially for those areas that also have a large "spark spread" – meaning that the cost of natural gas is low at the same time that the cost of electricity is high.[3] Some strategies for fuel cell deployment in Ohio in view of low cost natural gas are discussed further herein in Section III.

To date, Ohio has not been a leader in deployment of fuel cells for power generation. While states like California, New York and Connecticut have installed numerous fuel cell systems, Ohio has few active demonstration projects. The most significant active project in Ohio is a 1 MW fuel cell plant operated by FirstEnergy in Eastlake.[4]

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[1] Fuel cells that rely on natural gas as fuel cause carbon emissions when natural gas is steam reformed into hydrogen. However the EPA still places the carbon emissions from fuel cells (884 lbs) on a per megawatt-hour basis at far below burning coal (2249), oil (1672) or natural gas (1135). Some have argued that new combined cycle natural gas power plants can produce power with emission levels similar to those emitted from fuel cells on a per megawatt-hour basis. *See* E. Wesoff, "Bloom's Fuel Cells: Just How Green Is a Bloom Box," *Greentech Media*, September 4, 2013.

[2] For a list of nonattainment Ohio counties, *see* http://www.epa.gov/oaqps001/greenbk/anayo_oh.html.

[3] The spark spread is a common metric used for determining the profitability of gas-fired electric generation. It is calculated by comparing daily spot prices for natural gas and for power at various regional trading points. The greater the spark spread, the more profitable gas-fired generation should be. *See, e.g.* http://www.eia.gov/todayinenergy/detail.cfm?id=9911.
http://www.eia.gov/todayinenergy/detail.cfm?id=9911.

[4] There is also a 40 kW system operating at the U.S. Army National Guard facility in Columbus, Ohio, plus two 1 kW systems elsewhere. *See*: http://www.fuelcells.org/dbs/activities.cgim.

High (until recently) natural gas prices, however, are not the only reason for the lack of deployment of fuel cells in Ohio. Unlike California and New York, Ohio does not have a regulatory framework that encourages distributed generation (DG).[5] Yet fuel cells are almost exclusively designed for this market: stationary fuel cells typically range in size from around 5 kW to around 3 MW.[6] Ohio regulatory law, for instance, imposes standby power charges for some of the most cost-effective forms of DG, such as combined heat and power generation systems.[7] Fuel cells, however, do have one very important regulatory advantage under Ohio law: Net metering is available for fuel cells in Ohio as long as generation is not greater than on-site use.[8]

Ohio's generation market was deregulated in 2001, and as a result, in 2015 no return on investment is guaranteed in Ohio for generation. In recent years, power prices have been flat, and utilities have not invested significantly in new generation of any sort, much less those that deploy new technologies. In the meantime, Ohio utilities have lobbied the Public Utility Commission of Ohio to subsidize some of its old, traditional centralized generation.[9] The utilities argue that this is necessary because the alternative would be to shut down certain centralized generation facilities in Ohio, thereby putting Ohio at risk for having insufficient generation. Setting aside whether generation outside Ohio can cost effectively supply these markets, the argument ignores DG as an alternative to keeping old, inefficient centralized plants in operation.

DG offers power at or near the location where it is consumed. This reduces line losses as well as transmission and distribution costs. Moreover localized generation can also provide value to the grid as a whole: it relieves overall grid congestion, thereby reducing impedance, line losses and grid costs. It also increases grid security. The use of micro-grids and DG reduce the potential impact of grid attacks.[10] Programs that reduce

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[5] Distributed power generation refers to the small-scale power generation for delivery to locations nearby, usually on site. It ranges from very small scale (e.g. 5 kw – enough to power a typical house) to larger scales (e.g. 50 MW – enough to power an industrial plant).

[6] *See e.g.* "Stationary Fuel Cell Analysis," Hydrogen & Fuel Cell Research, http://www.nrel.gov/hydrogen/proj_fc_systems_analysis.html (system sizes tested by NREL's validation team at the National Fuel Cell Technology Evaluation Center).

[7] Although solid oxide and molten carbonate fuel cells operate at high temperatures, and may be candidates for combined heat and power applications, such systems may be limited by the complexity of meeting heat and power load requirements typical for CHP settings. *See e.g.* http://www.bloomenergy.com/fuel-cell/solid-oxide/. Moreover, some systems also use a portion of the heat in the hydrogen reformation process. *See* http://www.bloomenergy.com/fuel-cell/solid-oxide-fuel-cell-animation/. *But see*: "The New Power Generation: This Fuel Cell Startup Could Spark a Revolution," *GE Reports*, July 22, 2104http://www.gereports.com/post/92454271755/the-new-power-generation-this-fuel-cell-startup (reporting efficiency over 90% with heat recovery).

[8] Net metering may be limited in the event that total generation should pass a threshold amount of the aggregate utility customer demand. *See* Ohio Revised Code Section 4928.01(31)(a). *See also*: http://www.fuelcells.org/dbs/activity.cgim?id=1308&sess=9d468eca69e512af1d3e8e9fdfde160c&sel_state_0=%2C%22ohio%22&deployment=deployment&policies=policies&generation=generation.

[9] *See, e.g.* "Ohio Utility Providers Apply for Power Purchase Agreement Riders with PUCO," Kegler, Brown, Hill & Ritter, April 30, 2015, http://www.lexology.com/library/detail.aspx?g=7b6d9b21-46a5-4404-bbd8-3fc483504c3a. The utilities sought PUCO imposed riders to subsidize old, centralized power generation.

[10] For an assessment of the potential risk, *see* "Business Blackout: The Insurance Implications of a Cyber Attack on the US Power Grid," University of Cambridge, Centre for Risk Studies, 2015, found at:

waste, improve system security and increase grid efficiency should be supported by public policy. Finally, DG reduces emissions of carbon dioxide, particulates, nitrous oxides and sulfur dioxide – important issues for Ohio. In 2012, Ohio was generating 4.4% of the nation's carbon dioxide emissions, 9.6% of the sulfur dioxide and 4.2% of the nitrogen dioxide.[11] This was so despite the fact that Ohio only made up 3.6% of the nation's population.[12]

For the retail consumer, especially in those instances where net metering is allowed (such as for fuel cells), on-site DG may enable the consumer to not only obtain cheaper generation, but also to avoid distribution, rider, capacity, transmission, ancillary and other charges – costs that in Ohio in 2013 made up half of the cost of electricity.

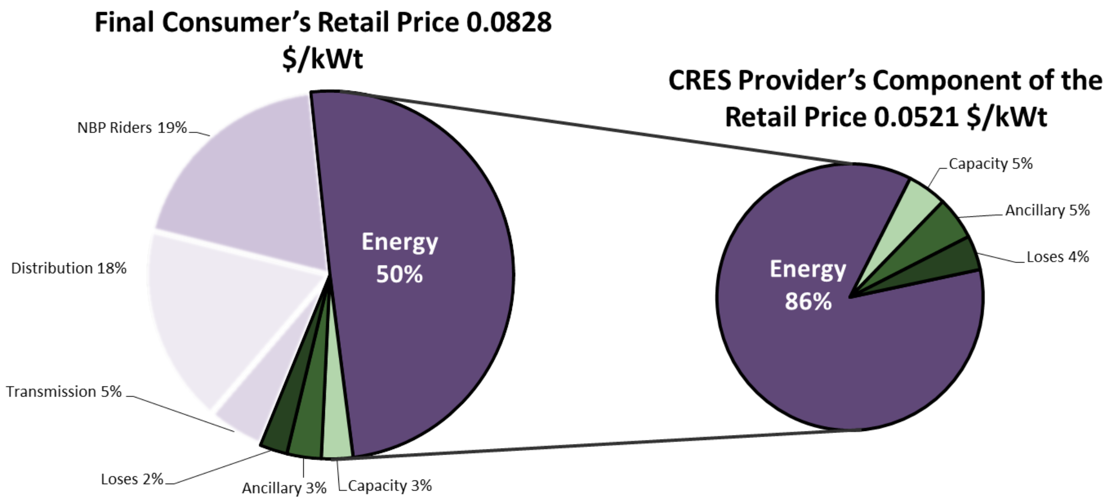

Figure 1. Structure of Ohio Retail Electricity Prices in 2013
Source: Scioto Energy

For Ohio, by 2015, the generation portion of the cost of electricity had dropped to well below half. This was because capacity prices in Ohio, especially northern Ohio, had skyrocketed. Capacity, which is the cost of standby power required to meet peak grid conditions, had risen from around 5% of the cost of wholesale power to around 37%. Total retail electricity costs rose significantly with this increase.[13] The result is that fuel cells now offer an even greater value, insofar as the cost of generation competes directly with a higher retail cost of delivered power.

Fuel cells are among the more promising forms of new DG technology available today. Many forms can run on natural gas, a readily available and cheap fuel. Further,

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https://www.lloyds.com/~/media/files/news and insight/risk insight/2015/business blackout/business blackout20150708.pdf
[11] http://www.eia.gov/state/data.cfm?sid=OH#Prices.
[12] *Id*.
[13] Thomas, Andrew R.; Lendel, Iryna; and Park, Sunjoo, "Understanding Electricity Markets in Ohio" (2014), page 28, *Urban Publications.* Paper 1268. Found at: http://engagedscholarship.csuohio.edu/urban_facpub/1268

fuel cells are ultra-efficient.[14] However if Ohio hopes to see the development of a fleet of its own stationary fuel cell systems, it must do more than rely on net metering rules and cheap natural gas. Like with any nascent technology, early adoption will require public-private financing strategies that will reduce the development risk for investors.

B. Stationary Fuel Cell Technology

There are four types of fuel cells that are generally considered to have a high likelihood of commercial success. Fuel cell technologies are typically categorized according to the electrolyte they use.[15] The two forms that are currently enjoying commercial deployment are the Solid Oxide Fuel Cells (SOFC) and the Proton Exchange Membrane (PEM) fuel cells. PEM cells can operate at lower temperatures, and are therefore susceptible of being turned on and off more easily. For this reason, PEM cells have been identified as most useful for either transportation or for peak loading. Higher temperature fuel cell technologies generally offer benefits of cost, efficiency, durability and adaptability to fuel sources. However, they are not easily turned on or off, and as a result, are better suited for base load stationary applications. SOFC in particular promises great efficiencies and in many applications can directly reform hydrogen from natural gas or other materials, making direct access to hydrogen unnecessary.[16]

Hydrogen is commonly made around the world for use as an industrial gas for such industries as petroleum refining and food processing. Typically it is made from natural gas through steam reforming. Steam reforming generally works best with economies of scale, and is usually undertaken in large-scale settings, where millions of cubic feet per day of hydrogen are produced. However hydrogen has generally been considered too valuable as an industrial gas to be used for power generation. In some places, such as where hydrogen is produced as a by-product of chlor-alkali operations and

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[14] Solid oxide systems, for instance, are capable of efficiencies of up to 65%. *See e.g.* "The New Power Generation: This Fuel Cell Startup Could Spark a Revolution," *GE Reports*, July 22, 2104http://www.gereports.com/post/92454271755/the-new-power-generation-this-fuel-cell-startup. Bloom Energy lists the efficiency for its 250 kW unit at a range of 52-60%. See: http://www.bloomenergy.com/fuel-cell/es-5710-data-sheet/. Efficiencies available for natural gas turbines are 50% and lower (*see* note 88, *infra*, and accompanying text) and for natural gas reciprocating engines are 33% and lower (*see e.g*. http://www.mge.com/saving-energy/business/bea/article_detail.htm?nid=1741). However some claim that combined cycle natural gas power plants can reach as high as 60%. *See* "Siemens Claims World's Most Efficient Gas Turbine, *Greentech Media*, November 16, 2011, found at http://www.greentechmedia.com/articles/read/siemens-claims-worlds-most-efficient-gas-turbine.

[15] There are five types of fuel cell technologies listed by the Department of Energy. *See* http://energy.gov/eere/fuelcells/comparison-fuel-cell-technologies. However most analysts consider alkaline fuel cells as appropriate only for special applications in the space industry.

[16] *See e.g.* http://www.bloomenergy.com/fuel-cell/solid-oxide-fuel-cell-animation/ (explaining how fuel is directly reformed into hydrogen). Two other fuel cell technologies that also show promise for stationary applications are Molten Carbonate (MCFC) and Phosphoric Acid (PAFC). MCFC has, so far, not enjoyed as many demonstrations as has SOFC. PAFC has had many demonstrations, and has proven to be extremely reliable. However PAFC operates at lower temperatures, does not promise the efficiencies of Solid Oxide and Molten Carbonate, and is less versatile with fuel options. *See* http://www.bloomenergy.com/fuel-cell/solid-oxide/ for a general description of some of the competitive advantages of solid oxide fuel cells.

there is no alternative market for the hydrogen, it may be burned as fuel for boilers. Such locations are good candidates to be among the first to exploit fuel cells on a utility scale – especially for those fuel cells that may not have onboard steam reforming built into the system, such as PEM and some PAFC systems.

The PEM cell is sensitive to impurities and requires high quality hydrogen.[17] Because hydrogen pipeline infrastructure in the United States is very limited, most PEM applications use hydrogen that is reformed at some distant location and shipped by truck or rail to the site where it will be used. An example of this is the First Energy 1 MW system in Eastlake, Ohio. This collaboration between First Energy and Ballard Power Systems uses hydrogen brought on site by a hydrogen supply company,[18] and is the largest PEM demonstration project in North America.[19] The high cost of hydrogen delivery in these sorts of settings can make stationary PEM cell economics difficult, and limit generation to high value peak load times.

With current low prices for natural gas, costs of making hydrogen are relatively low today. The result is that fuel cell systems that run directly on hydrogen may have more application in stationary power generation in Ohio. Indeed, low priced gas has already effected the value proposition for the transportation sector in Ohio. Recently, the Stark Area Regional Transit Authority was able to obtain for its fuel cell bus fleet a five year, fixed price contract for hydrogen at prices that are competitive with gasoline or diesel fuel.[20]

II. Available Public Sources of Funding for Stationary Fuel Cell Deployment.

A. State & Local Loan Programs

1. Property Assessed Clean Energy (PACE).

One of the most promising financing innovations for clean power in recent years is the Property Assessed Clean Energy (PACE) program. PACE takes slightly different forms across the nation,[21] but in general it can be thought of as the use of a special taxing district approach to encourage and fund the adoption of renewable and alternative energy. The basic premise behind PACE is that, in most cases, governments at the local level

[17] http://energy.gov/eere/fuelcells/comparison-fuel-cell-technologies.
[18] "FirstEnergy Tests Largest Utility Scale Fuel Cell System," September 2011, https://www.firstenergycorp.com/content/fecorp/environmental/environmental_stewardship/alternative_renewableenergy/fuel_cell.html.
[19] "FirstEnergy Fuel Cell Demonstration Project," *CleanEnergy/Action Project*, http://www.cleanenergyactionproject.com/CleanEnergyActionProject/Fuel_Cells_Case_Studies_files/FirstEnergy%20Fuel%20Cell%20Demonstration%20Project.pdf.
[20] Interview with Kirt Conrad, CEO, Stark Area Regional Transit Authority, Canton, Ohio, July 10, 2015. SARTA was able to obtain hydrogen gas for its fuel cell bus fleet at a cost of $4.59/kg. The gas is manufactured in Sarnia, Ontario, and delivered to SARTA by truck. *Id.*
[21] Thirty states and the District of Columbia have passed PACE enabling legislation—though each state has passed slightly different versions of the PACE legislation.

issue municipal bonds and then loan out the money generated from the bond sales to finance these loans to commercial/industrial properties.[22] Having local governments finance these improvements may also provide financing to some with poor credit, but most programs have bank-like standards. PACE provides a low-cost alternative to other loans and provides a longer repayment schedule, and creates a loan that is tied to the property rather than the owner of the property (something not seen in most of forms of energy financing). The loan is then repaid back to the local government over 15-20 years—with the key feature being that the loan repayment is added to the property tax bills rather than being repaid like a traditional loan. Consequently the loan does not get paid off at the transfer of the property; rather it stays with the property not the owner. This reduces the investment risk for property owners, better assuring long-term capitalization. In nearly all cases the PACE loan has seniority on the mortgage, meaning it gets paid off first in case of foreclosure—which is why it is not use in most states for residential loans because Fannie Mae and Freddie Mac are unwilling to accept these on loans they purchase. Since the two entities own more than half of US mortgages, PACE now goes largely unused in the residential sector.

The mechanics of how a homeowner or business owner navigates PACE is relatively straightforward. A contractor provides an estimate of the renovations or purchases, the property owner will then submit:

> "an application to the municipality, whose staff reviews the scope of work and checks that they have a clear property title. After the municipality approves the application, the work is completed, a lien is placed on the property, and a check is issued to the property owner. A special tax is added to future property bills. If the property is sold before the end of the 20-year repayment period, the new owner pays the remaining special taxes as part of [his] property's annual tax bill. The interest component of the special tax payments will be tax deductible, similar to a home equity line or home mortgage.[23]

PACE offers comparative advantages for property owners in terms of tax advantages, interest rates, and length of repayment. Interest on a PACE loan can be deducted on income tax filings[24], something that cannot be done with many other types of loans. The rates offered by PACE communities have been consistently lower than that which most commercial loan products have offered, though not always. Non-refinancing options available via traditional loan products that cover green retrofits, like insulation,

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[22] The city of Desert Palms, CA used general fund revenue to support their first round of financing, and bonds in later rounds. (M. Fuller, S. C. Portis, and D. M. Kammen, "Toward a Low-Carbon Economy: Municipal Financing for Energy Efficiency and Solar Power," Environment: Science and Policy for Sustainable Development, vol. January-February, 2009).

[23] M. Fuller, S. C. Portis, and D. M. Kammen, "Toward a Low-Carbon Economy: Municipal Financing for Energy Efficiency and Solar Power," Environment: Science and Policy for Sustainable Development, vol. January-February, 2009, § 3.

[24] M. Fuller, C. Kunkel, and D. M. Kammen, "Guide to energy efficiency and renewable energy financing districts for local governments | Renewable and Appropriate Energy Laboratory," University of California, Berkeley, Berkeley, CA, 2009.

new efficient furnaces, or PV solar panels would require payback over 5-7 years.[25] This shorter payback period increases the burden of the high upfront cost. PACE will allow for the life expectancy of the benefits of the green retrofits to more closely match the repayment plan.

PACE loans can finance a wide-range of energy efficiency and electricity generating projects from insulation to geothermal heating to solar PV to fuel cells. And in some states the program's water efficiency retrofits are being added to the mix of acceptable projects.

1.1. What does PACE accomplish that other government programs do not?

It has been noted that there are various barriers to a more widespread adoption of these efficiency and energy generation technologies in homes and commercial properties, because they "include lack of information, transaction costs, principal-agent barriers, and high first cost."[26] The design of PACE is to primarily address the last of these barriers—the high first (or upfront) cost.

Surmounting the barriers to a lack of information is difficult in itself. Property owners may intrinsically know that better insulation, for example, can save money, but the investment may feel like a risk because they cannot accurately predict how much money they will actually save. If a property owner rents the property, then the motivation to improve efficiency is somewhat limited, further complicating the incentive stream from purchaser to benefactor. And others may not feel that the transaction cost necessary to seek out information on green home improvements and the PACE financing mechanism are worth the hassle.[27]

Once the barriers of information, transaction cost, and principle-agent are overcome, the challenge of surmounting the psychological and financial barrier of spending thousands, hundreds of thousands, or millions of dollars to install fuel cells or other technologies is still quite high. The calculation of true savings of the investment in efficiency and energy technologies are difficult and abstract for the average commercial business or homeowner. Many of these systems are already cost-effective, meaning they have a reasonable payback time frame, when other state and federal subsidies afforded to property owners are used, but again it is that high first cost that is difficult to get around. PACE can be used in combination with the other tax programs mentioned in this paper to mitigate some of these initial costs.

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25 M. Fuller, S. C. Portis, and D. M. Kammen, "Toward a Low-Carbon Economy: Municipal Financing for Energy Efficiency and Solar Power," Environment: Science and Policy for Sustainable Development, vol. January-February, 2009.

26 M. Fuller, C. Kunkel, and D. M. Kammen, "Guide to energy efficiency and renewable energy financing districts for local governments | Renewable and Appropriate Energy Laboratory," University of California, Berkeley, Berkeley, CA, 2009.

27 M. Fuller, S. C. Portis, and D. M. Kammen, "Toward a Low-Carbon Economy: Municipal Financing for Energy Efficiency and Solar Power," Environment: Science and Policy for Sustainable Development, vol. January-February, 2009.

1.2. Use and Availability of PACE for Fuel Cells in Ohio

In the state of Ohio legislation has been passed to enable PACE districts[28], which allows for the use of special improvement districts to be created by local governments in the state to fund the PACE programs. In Ohio PACE funding is currently limited to "Alternative energy technologies limited to solar photovoltaic projects, solar thermal energy projects, geothermal energy projects, and customer-generated energy projects".[29] SB 232 defines "Customer-generated energy projects" as those that are "wind, biomass, or gasification facility for the generation of electricity" that are not selling directly to the public and are located on the customer's site (i.e. not mobile or remotely located).[30]

These current statutory limitations preclude fuel cells from being financed through PACE in Ohio. However, a number of other states currently allow PACE to finance fuel cells—providing Ohio legislators with a model for future changes. New York, Connecticut, California, Colorado, Florida, Nebraska, New Jersey, Wisconsin, and Rhode Island all have legislation in place that allows for the funding of fuel cells through PACE.[31]

Legislation recently introduced to the Ohio legislature (SB 185) has the potential to dramatically streamline and simplify the PACE process—in fact it would remove "the requirement to create or join an [Energy Special Improvement District] to use PACE financing."[32] The removal of this requirement would allow property owners to use the same financing mechanism without a PACE program in place, which would presumably lower administrative costs.[33] SB 185 would also allow for non-contiguous creation of PACE districts, improving the economies of scale of PACE—larger area, larger bond issuance, larger risk pool, and ultimately lower loan rates. From speaking with the Cincinnati administrators of the regional PACE program there, it is clear that the

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28 Ohio Revised Code, Chapter 1710: SPECIAL IMPROVEMENT DISTRICTS, 2010; Ohio Revised Code, 717.25 Low-cost alternative energy revolving loan program, 2010; Ohio Revised Code, SB 232. 2010.

29 Ohio Revised Code, SB 232. 2010.

30 Ohio Revised Code, SB 232. 2010.

31 See: US Department of Energy, "State of the States: Fuel Cells in America 2014 (5th Edition)." US Department of Energy, Dec-2014. Florida Green Energy Works, "Eligible Measures," 2015. Available: http://www.floridagreenenergyworks.com/finance-program,eligible-measures. Open EI, "PACE Financing," 2015. Available: http://en.openei.org/wiki/PACE_Financing. City of Milwaukee, "Property Assessed Clean Energy (PACE) Finance - Program Manual." 04-Oct-2013. NC Clean Energy Technology Center, "Local Option - Property Assessed Clean Energy Financing," 26-Jun-2015. Available: http://programs.dsireusa.org/system/program/detail/5109. NC Clean Energy Technology Center, "Local Option - Municipal Sustainable Energy Programs," 10-Jul-2015. Available: http://programs.dsireusa.org/system/program/detail/3765.

32 Bricker, E. L.-J. C. Bell, and C. J. Kalvas, "S.B. 185 would significantly simplify PACE financing in Ohio | Lexology," 17-Jun-2015. Available: http://www.lexology.com/library/detail.aspx?g=76a37b1f-bbec-4746-860f-555bc46732c4.

33 Bricker, E. L.-J. C. Bell, and C. J. Kalvas, "S.B. 185 would significantly simplify PACE financing in Ohio | Lexology," 17-Jun-2015. Available: http://www.lexology.com/library/detail.aspx?g=76a37b1f-bbec-4746-860f-555bc46732c4.

administrative burdens of setting up the PACE program have been substantial—and thus require substantial political and financial incentives pushing for their adoption. Consequently, SB 185 has the potential to push PACE-like financing into the mainstream across the state of Ohio because it would dramatically lower the administrative burden of setting up regional PACE programs. It should be noted that even with the passage of SB 185, as written, fuel cells would still *not* be an allowable project to finance.

Other legislation (HB 72) that has been introduced, but not passed, has the potential to expand the definition of what could be financed via PACE. This expanded definition would seem to include fuel cells, through the addition of "fuel source conversion projects." The proposed legislation defined a "fuel source conversion project" as "a project undertaken by a property owner, rural cooperative, or political subdivision of this state to convert an existing fossil fuel based technology, product, or system to a more efficient technology, product, or system, including conversion to a natural gas or electricity-based technology, product, or system."[34] HB 72 has been sent back to committee, thus is unlikely to be passed in 2015.

2. Energy Loan Fund

The state of Ohio's Development Services Agency administers the Energy Loan Fund. The ELF "provides low-cost financing to small businesses, manufacturers, nonprofits, and public entities for energy improvements that reduce energy usage and associated costs, reduce fossil fuel emissions, and/or create or retain jobs."[35]

Funds are available to distributed energy technologies that significantly increase energy efficiency, including but not limited to district heating and cooling projects, combined heat and power, cogeneration systems, and biomass systems.[36] Projects must achieve 15 percent reduction in energy usage, demonstrate economic and environmental impacts and be included within a long-term energy strategy.[37] A total of $11.25 million is available in the fiscal year 2016, with minimum and maximum loan size ranging from $250,000 to $1.25 million.[38] Loan terms and rates are determined on a case-by-case basis, depending upon the project payout and other factors. Loan rates will be below the prime rate published in the Wall Street Journal.[39]

Projects meeting these requirements must submit a letter of intent with the Ohio Development Services Agency for funding before August 12th, 2015 for this round of funding. To date no fuel cell projects have been funded through this funding mechanism.

B. Federal Loan and Grant Programs

[34] Legislation proposed by M. Conditt: *HB 72*. 2015.
[35] Ohio Development Services Agency, "Energy Loan Fund," 25-Jun-2015. Available: http://development.ohio.gov/bs/bs_energyloanfund.htm
[36] http://development.ohio.gov/files/bs/Energy%20Loan%20Fund%20Guidelines.pdf
[37] http://development.ohio.gov/bs/bs_energyloanfund.htm
[38] *Id*.
[39] http://development.ohio.gov/files/bs/ELF%20QA-1.14.13.pdf

1. Qualified Energy Conservation Bonds (QECBs)

Qualified Energy Conservation Bonds are funded by the federal government and distributed by state and local governments. QECBs are "among the lowest-cost public financing tools because the U.S. Department of the Treasury subsidizes the issuer's borrowing costs."[40] In Ohio, QECBs are administered by the Ohio Air Quality Development Authority; however funds may be paid out directly by the federal government.[41]

QECBs were authorized by Congress in the 2008 Energy Improvement and Extension Act. The original legislation authorized just $800 million of QECBs nationwide. In 2009, Congress increased that number to $3.2 billion in funding for states, territories, large local governments, and tribal governments to issue QECBs to finance renewable energy and energy efficiency projects. Several QECB projects have already been undertaken in Ohio, including allocations of $518,006 for projects in Findlay, $386,146 in South Euclid, and $1,557,500 in Pickaway.

QECB proceeds are not as restrictive as renewable energy funds and could be used to fund a fuel cell project fueled by natural gas. The bonds are available for, among other uses: "designing/running demonstration projects to promote the commercialization of energy-related technologies and processes," "developing rural capacity", and "capital expenditures in public buildings that reduce energy consumption by at least 20%."[42] According to the EPA, "Fuel cells and micro-turbines are listed technologies that are supported."[43]

2. U.S. DOE - Innovative Clean Energy Project Loan Guarantees

These loans are available for projects that are "catalytic, replicable and market-ready."[44] The Department of Energy 2015 solicitation seeks to fund loans made to support "Advanced Grid Integration and Storage," projects that include "renewable energy generation, including distributed generation, incorporating storage." If the fuel cell project can incorporate these features it may be eligible for a loan.[45]

3. United States Department of Agriculture Rural Energy for America Program

REAP "provides financial assistance to agricultural producers and small businesses in rural America to purchase, install, and construct renewable energy systems,

[40] US Department of Energy, "Qualified Energy Conservation Bonds," 2015. Available: http://energy.gov/eere/slsc/qualified-energy-conservation-bonds
[41] http://www.ohioairquality.org/oaqda/default.asp
[42] 26 U.S. Code § 54D - Qualified energy conservation bonds
[43] http://www.epa.gov/chp/policies/incentives/uqualifiedenergyconservationbondsqecbs.html
[44] US Department of Energy, "Energy Department Makes Additional $4 Billion in Loan Guarantees Available for Innovative Renewable Energy and Efficient Energy Projects," Energy.gov, 03-Jul-2014. Available: http://energy.gov/articles/energy-department-makes-additional-4-billion-loan-guarantees-available-innovative-renewable.
[45] US Department of Energy, "Loan Guarantee Solicitation Announcement & Supplement." 22-Apr-2015

make energy efficiency improvements to non-residential buildings and facilities, use renewable technologies that reduce energy consumption, and participate in energy audits and renewable energy development assistance."[46] Fuel Cells using renewable fuels would be eligible to secure REAP funding. In 2014, no fuel cell projects received any of the nearly $69 million in funding, but several biomass projects did receive awards. The USDA offers combinations of grants (covering up to 25%) and loan guarantees (up to 75%) to fund renewable energy systems.

C. Federal Tax Programs

1. Business Energy Investment Tax Credit (ITC)

Business have access to Investment Tax Credits (ITC) that will provide up to 30% of the cost, not exceeding $3,000/kW, for fuel cell purchase/install, through the end of 2016.[47] The ITC is available to a fuel cell system that has (i) a nameplate capacity of at least 0.5 kilowatt of electricity using an electro-chemical process, and (ii) an "electricity-only" generation efficiency greater than 30 percent.[48] The credit provides 30% of expenditures, but is capped at a maximum of $1,500 for each 0.5 kilowatt of capacity of a system approved before December 31, 2016.

The ITC cannot be combined with the PTC (discussed below), but the ITC would in most cases be preferable to the PTC because it accelerates the benefits and helps reduce high upfront costs. This tax credit is intended to facilitate outside investment by reducing the payout period to a timeframe investors can tolerate. An example of how the ITC can be used in California to reduce up front fuel cell installation costs is set forth in Figure 2, below.

2. Clean Renewable Energy Bonds (CREBs)

These are available only for renewables. In the context of fuel cells this includes open and closed loop bio mass systems and other sources of renewable fuel. In the summer of 2015 the IRS was soliciting applications for allocations of the remaining available amount of the national limit (volume cap) for new clean renewable energy bonds.[49]

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[46] NC Clean Energy Technology Center, "USDA - Rural Energy for America Program (REAP) Loan Guarantees," 09-Dec-2014, found at: http://programs.dsireusa.org/system/program/detail/2511.
[47] Ballard Power Systems, "U.S. Hydrogen and Fuel Cell Fiscal Incentives." Apr-2011.
[48] 26 U.S.C. §48(c)(1)
[49] IRS Notice 2015-12

FUEL CELL TECHNOLOGIES OFFICE

Example Cost Comparison for a 300 kW Fuel Cell Combined Heat and Power System in California: Fuel Cell Purchase vs. a Ten-Year Fuel Cell Service Contract

Tax Status of Owner	Case 1: Energy User Purchases and Installs System Tax-exempt	Case 2: Energy User Holds Service Contract for System Taxpayer
Installed Cost		
Purchased Price	$1,500,000	$1,500,000
Installation Expenses	584,000	584,000
Sales Tax (California)	0	105,000
Third-Party Financing Expenses	0	60,000
Installation Cost	$2,084,000	$2,249,000
State Grant (California location and eligibility)[3]	(750,000)	(750,000)
Federal ITC[4]	0	(675,000)
ITC Financing and Transaction Expenses[5]	0	200,000
Net Installation Cost	$1,334,000	$1,024,000
Net Installation cost impact to energy user	**$1,334,000**	**$0[6]**
Annual Energy Operating and Maintenance (O&M) Costs		
Annual Maintenance Cost	$150,000	$150,000
Annual Fuel Consumption	175,000	175,000
Annual Energy Savings	(289,000)	(289,000)
Third-Party Financing Costs[7]	0	117,000
Net Annual Energy O&M Costs	$36,000	$153,000
Cumulative O&M cost impact to energy user (10 years)	**$360,000**	**$1,530,000**
TOTAL COST IMPACT TO ENERGY USER	**$1,694,000**	**$1,530,000**
TOTAL COST IMPACT TO ENERGY USER, Present Value[8]	**$1,525,000**	**$1,126,000**
COST SAVINGS TO ENERGY USER, Present Value	**0**	**$399,000**

The **Investment Tax Credit (ITC) reduces the project developer's up-front costs by 23%** in Case 2 (from $1,334,000 to $1,024,000) compared to the energy user's up-front costs in Case 1, who is ineligible for the ITC. The energy user can indirectly benefit from the tax credit, assuming the developer passes the ITC tax savings through the service contract in Case 2.

Since the contract services in Case 2 are payable over time, the energy user avoids the up-front installation costs of $1,334,000.

The fuel cell provides power and avoids grid charges. Example: Assuming grid charges of $289,000/year, $2.89M grid charges over 10 years—$1.53M service contract over 10 years = **$1.36M grid charges avoided** over 10 years in Case 2.

The use of a service contract in Case 2 by the energy user enables the project developer to acquire, install, and operate the system and pass the ITC tax savings to the energy user. Case 2 will **reduce the life-cycle costs to the energy user by 26%** or $339,000 on a present-value basis over the 10-year life of the project (from $1,525,000 to $1,126,000) when compared to Case 1.

Figure 2. Cost Comparison of CHP and Fuel Cells in California
Source: Fuel Cell Technologies Office

3. Renewable Electricity Production Tax Credit (PTC)

Production tax credits[50] are incentives that provide financial support for renewable energy. For fuel cells, this appears to limit application to those instances when the fuel cell us run off of renewable sources of gas. Biogas would be the most likely source of hydrogen for a renewable fuel cell project. There have been a number of such projects to date, especially associated with water treatment facilities.

The production tax credit provides a tax credit of between 1.1 to 2.3 cents per kilowatt-hour (kWh) incentive, depending upon the nature of the renewable system, for the first ten years of a renewable energy facility's operation. However, in January 2015 the U.S. Senate declined to extend this program, so its future is uncertain.[51]

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[50] https://www.wsgr.com/PDFSearch/ctp_guide.pdf
[51] http://www.eenews.net/stories/1060012507; *see also* "Production Tax Credit for Renewable Energy," Union of Concerned Scientists, found at: http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/production-tax-credit-for.html#.VamFDUWR814

D. State Tax Programs

1. Air-Quality Improvement Tax Incentives

These tax credits are available to renewable and advanced energy projects and can be used on "any fuel cell used in the generation of electricity, including, but not limited to, a proton exchange membrane fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, or solid oxide fuel cell."[52] These credits can provide up to 100% exemption from tangible personal property taxes, real property tax, a portion of the personal property tax, and sales and use tax, and the income from interest is exempt from state income tax.[53]

2. Qualified Energy Property Tax Exemption for Projects Over 250 kW

This tax incentive allows a payment in lieu of public utility tangible personal property taxes and real property taxes. Renewable energy projects under 250 kWh were permanently exempted from the public utility tangible personal property tax under S.B 232.[54] Renewable energy facilities over this threshold must apply to the Ohio Development Services Agency (ODSA) for certification as a "qualified energy project." In order to qualify, the owner or lessee subject to sale or leaseback transaction must apply to Development Services Agency on or before December 31, 2015 for renewable energy projects and before December 31, 2017 for clean coal, advanced nuclear, and cogeneration projects.[55] It would appear, then, that for a fuel cell project to qualify, it may have to either be run from a renewable energy source, or it must have a heat recovery capability.

Applications must be received before December 31, 2015 and placed in service before December 31, 2017. In lieu of taxes, payments are made to the county of between $6000 to $8000/MW must be made, depending upon the type of technology and the percentage of Ohio-based employees the company has. All other qualified facilities employing at least 50% Ohio-based employees during construction: $8,000/MW.[56]

The state of Ohio has created provisions in the tax code to exempt energy generation facilities of any type of 250 kW or less. Those facilities are "permanently exempt from the public utility tangible personal property tax and real property taxes." The Ohio Development Services Agency administers the program.

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[52] ORC 3706.25(B)(4)

[53] http://programs.dsireusa.org/system/program/detail/78. The Ohio Air Quality Development Board is the conduit through which business receives tax incentives if the loan qualifies. *See:* http://www.ohioairquality.org/oaqda/faqs.asp#2

[54] http://programs.dsireusa.org/system/program/detail/4311

[55] http://development.ohio.gov/bs/bs_qepte.htm

[56] http://programs.dsireusa.org/system/program/detail/4311

3. Energy Conversion and Thermal Efficiency Sales Tax Exemption

The Conversion Facilities Tax Exemption, administered by the Ohio Department of Taxation, may provide an exemption from certain property state sales and use taxes for property used in energy conservation, thermal-efficiency improvements and the conversion of solid waste to energy.[57] A fuel cell probably qualifies as an "energy conversion facility" ("any property or equipment designed, constructed, or installed after December 31, 1974, for use at an industrial or commercial plant or site for the primary purpose of energy conversion").[58] Waste heat recovery systems also qualify.

E. Other State Financing Strategies

1. Public Utility Economic Development Riders

The Public Utility Commission of Ohio (PUCO) has been granted broad authority by the Ohio General Assembly to ensure the availability of an adequate, reliable and efficient retail electric service.[59] Several of the large incumbent utilities in Ohio sought PUCO support through this authority to pay for aging coal and nuclear plants that were no longer cost effective. The utilities asked the PUCO to approve "Power Purchase Agreements" (PPAs) that would guarantee that the plants would remain profitable for at least 15 years. Regulators rejected American Electric Power Inc.'s request, but in so doing determined that such power purchase agreements were legal.[60] First Energy's request for a PPA subsidy was still pending as of July 2015.

Under the proposed power purchase agreement all customers in the regulated region would pay a fee in the form of a rider to make up the difference between market rates and the PPA. The PUCO determined it had the authority to grant this and other PPAs under its authority to ensure a secure retail service. A number of stakeholders disagreed, arguing that allowing the PUCO to award a PPA to a generating company would subvert the legislative intent of deregulation. The matter has not, however, worked its way through Ohio courts, insofar as the dispute is moot so long as PUCO continues to deny utility requests for PPAs on other grounds.

Regardless of what authority the PUCO may have to award PPAs, the PUCO can accomplish something similar through its authority under state law to award "special arrangements" to establish electric service at a discounted price for purposes of economic development. Under this law, a mercantile customer may propose a "reasonable

[57] http://development.ohio.gov/bs/bs_contaxexempt.htm

[58] ORC 5709.20(C)&(D). Program information can be found at: http://programs.dsireusa.org/system/program/detail/77

[59] Ohio Revised Code Section 4928.02(A).

[60] *See* T. Knox, "AEP Loses Out as Regulators Reject Deal for Guaranteed Income," Columbus Business First, February 25, 2015, found at: http://www.bizjournals.com/columbus/blog/ohio-energy-inc/2015/02/aep-loses-out-as-regulators-reject-deal-for.html

arrangement" which the PUCO may modify and approve.[61] The costs of the discount are passed through to the ratepayers through a rider. To establish the merit of the arrangement, the recipient must establish that the benefits to the region paying the rider offsets the revenue paid by the region's ratepayers to support the arrangement. The Commission may approve the application if it determines that the arrangement is "just and reasonable." The most controversial example of such a special arrangement was for Ormet Aluminum Corporation, which company had received over $300 million in rate subsidies only to subsequently close up shop in 2013.[62]

Through either its authority to approve special arrangements or to award PPAs (or both), the PUCO has the authority to support generation from a fuel cell facility. However the PUCO will require a compelling case for system improvement and/or job creation before approving such an arrangement. Such a case might be made by a fuel cell system manufacturer or supplier based in Ohio.

2. Renewable and Advanced Energy Portfolio Standards

In 2008 Ohio passed renewable and advanced energy portfolio standards (Senate Bill 221), both of which included programs to support fuel cells. Under Ohio Revised Code Article 4928.64-65, Ohio was required to ensure that 25% of electricity sold by Ohio electric distribution companies to be from "alternative energy sources" by 2025. Alternative Energy refers to both "advanced energy" and "renewable energy" sources, with one half the mandate met by each.

Technologies that qualified for renewable energy include "any fuel cell used in generation of electricity." Notably, the statute does not require that the fuel cell derive its power from a renewable fuel. The renewable portfolio is supported by benchmarks. Utilities could meet the mandate either though purchasing qualifying power or though purchasing renewable energy credits. One credit is equal to one megawatt-hour of qualifying generation.[63]

The other half of the mandate – the advanced energy side – also includes "any fuel cell used in the generation of electricity." However the Ohio Assembly did not set benchmarks for the advanced energy side, and as a result, no market for advanced energy credits has been created.

Beginning in 2014, Ohio utilities began a campaign to roll back the alternative energy portfolio, persuading members of the Ohio General Assembly to introduce various forms of legislation that would alter or terminate the mandates. Ultimately the Ohio General Assembly compromised, passing Senate Bill 310, which imposed a freeze on the renewable energy portfolios until 2017, pending a review by the Assembly as to the financial effects of the portfolio standards on the Ohio economy, and eliminated the

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[61] Ohio Revised Code Section 4905.31. For a general description of SB 221, *see* "Green Strategies Bulletin, Bricker & Eckler, January 2014, found at: http://www.bricker.com/documents/Publications/1533.pdf.

[62] D. Gearino, "Ormet Will Close," *The Columbus Dispatch*, October 5, 2013, found at: http://www.dispatch.com/content/stories/business/2013/10/04/ormet-shutting-down.html.

[63] Ohio Revised Code Scction 4928.65.

advanced energy mandate.[64] In Ohio General Assembly appointed a committee to report on this issue in September 2015.

The result is that it is difficult today to predict what sort of support will be available, if any, from Ohio's renewable energy mandate. In early August 2015, federal Environmental Protection Agency set forth carbon reduction regulations that will require Ohio and other states to significantly reduce carbon emissions by 2030.[65] It appears that Ohio's General Assembly will have to, as a result, reinstate at least a portion of the renewable and energy efficiency mandates in some fashion. But it is too early to know how aggressive that mandate will be, or what the value of Renewable Energy Credits might be from such generation.

F. Successful Programs in Other States

1. Connecticut Micro-Grid Program

The State of Connecticut has sponsored two rounds of funding for a Micro-Grid Development program.[66] Micro-grids can provide a vital power source during times of emergency when primary power sources are knocked out, or damage has been done to the grid, disconnecting parts of the state from their typical power source. The primary goal of these micro-grid projects is to "support critical facilities and are to be distributed evenly between small, medium, and large municipalities" during times of emergency.[67]

In Connecticut's program they fund the "cost of design, engineering services, and interconnection infrastructure" through the grants. In the first two rounds of funding (of two total) the State has funded three fuel cell projects to help develop the state's micro-grid infrastructure.[68] One project is located at the University of Connecticut (Round 1), one for the Town of Woodbridge (Round 1), and one at the University of Bridgeport (Round 2). These grants have provided more than $7 million in funding to these three projects—and are generating about 2.2 MW of electricity.

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[64] Most of the controversy over SB 310 dealt with the freeze on the renewable portfolio mandate and the energy efficiency portfolio mandate. As a result, little has been said about eliminating the advanced energy mandate. *See e.g*. "A Balanced Discussion on the Merits of SB 310," All Energy Consulting, July 2, 2014, found at: http://allenergyconsulting.com/blog/2014/07/02/a-balanced-discussion-on-the-merits-of-sb-310-throwing-the-baby-out-with-the-bathwater/.

[65] See J. Piper, "Obama Finalizes Landmark Carbon Regulations," *Greentechmedia*, August 3, 2015, found at: http://www.greentechmedia.com/articles/read/obama-administration-to-finalize-climate-rule-with-new-flexiblity-measures?utm_source=Daily&utm_medium=Headline&utm_campaign=GTMDaily

[66] Connecticut Department of Energy & Environmental Protection, "Microgrid Grant and Loan Program," Dec-2014. [Online]. Available: http://www.ct.gov/deep/cwp/view.asp?a=4120&Q=508780.

[67] *Id*.

[68] *Id*.

2. Self-Generation Incentive Programs

California has led the way with the adoption of distributed generation through its Self Generation Incentive Program (SGIP). The program provides incentives for certain types of distributed energy resources. Among the qualifying technologies are fuel cells.[69] Since the program began, over 544 projects have been completed, producing around 252 MW of power.[70] It was originally conceived as a peak load program in response to the 2001 energy crisis in California, but has since evolved into a program that supports California's power infrastructure.

The program buys down the cost of installing qualifying DG generation projects by paying a price in dollars per watt of installed capacity. Fuel cells fall into the category of "emerging technologies," and fuel cells that use non-renewable fuel sources receive $1.65/watt (or $1,650/kW) installed.[71]

There can be little doubt that California's SGIP is designed to enable the adoption of fuel cells. Of the 252 MW of generation capacity built through the SGIP, around 15% (38 MW) is fuel cell generation. Yet California has spent $191 mm on fuel cells through the SGIP, which represents about 69% of the total funds spent on various technologies. Most of the capacity has been built in the San Francisco area.[72] The National Fuel Cell Research Center (University of California, Irving) set forth the value proposition of stationary fuel cells running on natural gas by examining both internal (e.g. avoided grid costs) and external (e.g. environmental and health) cost savings. Those values ranged from between 5 and 20 cents per kWh.[73]

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[69] http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/

[70] http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/aboutsgip.htm

[71] *Id.*

[72] http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/SGIPstats_through12-31-08.htm

[73] *See* "Build up of Distributed Fuel Cell Value in California: 2011 Update," at 4 (2011); found at: http://www.nfcrc.uci.edu/3/FUEL_CELL_INFORMATION/MonetaryValueOfFuelCells/Fuel_Cell_Value-Methodology_2011_FINAL_072411_Large-Units_Final.pdf. Some of the values included credits for cogeneration, which may or may not be possible depending upon the circumstances.

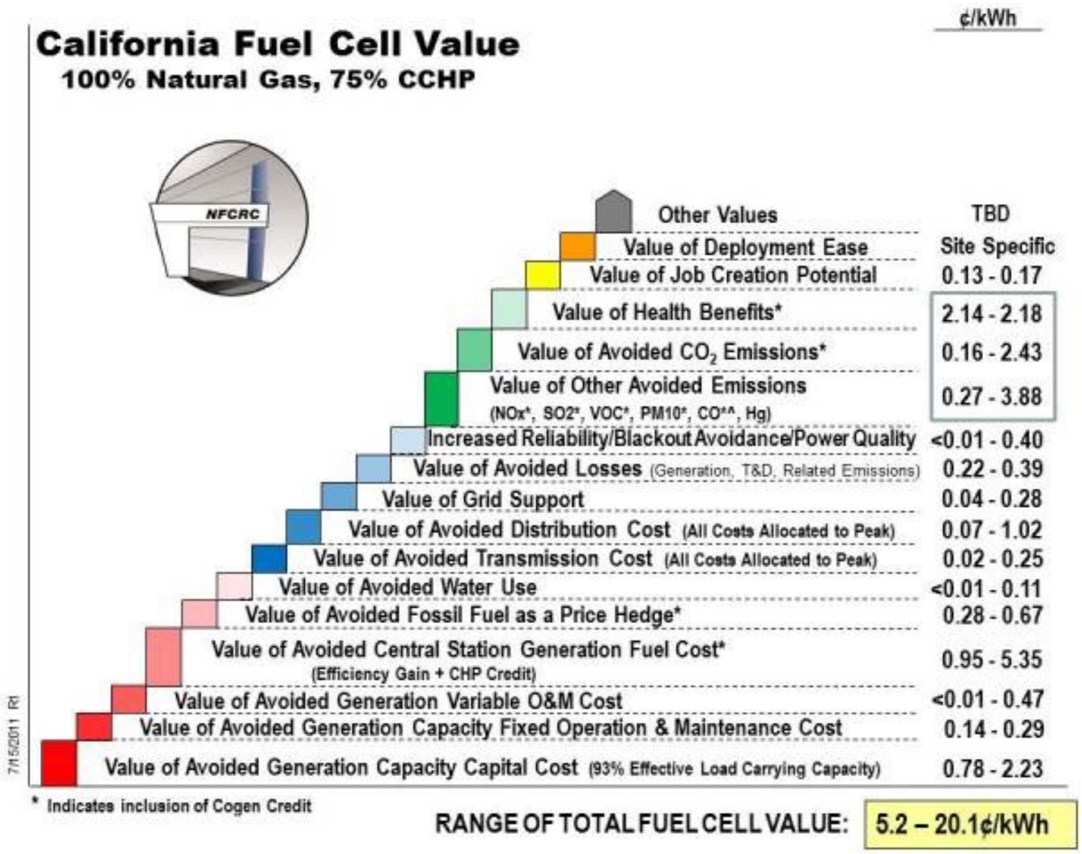

Figure 3. California Fuel Cell Value Proposition
Source: National Fuel Cell Research Center

3. Feed-In Tariffs

A feed-in tariff (FIT) is a guarantee of a certain price, usually above market rate, for each kWh of energy produced from renewable or advanced energy sources for a guaranteed period of time (often 15-20 years).[74] European countries like Denmark, Spain, and Germany have used them to increase their renewable energy. United States began to follow with states like Florida and Vermont leading the way.[75] However the Independent Electricity System Operator in Ontario administers the most comprehensive FIT program in North America. That program does not support fuel cells unless is uses biogas or landfill gas as the fuel source. The Ontario FIT program is designed for systems between 10 and 500 kW.[76] As Ontario discovered, FIT programs can be expensive and controversial.[77]

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[74] http://energy.gov/eere/slsc/renewable-energy-utility-scale-policies-and-programs
[75] For a list of state FIT programs- http://www.eia.gov/electricity/policies/provider_programs.cfm
[76] http://www.energy.gov.on.ca/en/fit-and-microfit-program/.
[77] *See e.g.* P. Gallant, "Ontario's Power Trip: Not a FIT Review," *Financial Post*, March 22, 2012, found at: http://business.financialpost.com/fp-comment/ontarios-power-trip-not-a-fit-review

III. Strategies for Commercial Success of Stationary Fuel Cells In Ohio.

A. Fuel Cells Using Natural Gas as Fuel

Many fuel cells contain "onboard" fuel processing, meaning that they have the ability to directly convert natural gas to hydrogen as part of the fuel cell system. Solid Oxide fuel cells, which run at high temperatures, generally have this capability.[78] These fuel cells are able to operate from any location where there is a natural gas fuel supply. The promise of a long term source of cheap natural gas has made the economics of these systems more interesting in places like Ohio that have traditionally relied upon coal as its main source of power generation because of cost.

Ohio, in 2015, appears to be enjoying the sort of conditions necessary to support investment into natural gas-based generation. Market conditions are such that long-term natural gas purchase contracts can be negotiated at prices not imagined possible ten years ago.[79] Long term contracts for fuel supply that contain fixed or hedged prices are important to trigger the financing necessary to build fuel cell generation.

In 2005, the U.S. average city-gate (local distribution company delivery point) price for natural gas was over $10 per thousand cubic feet (mcf). In Ohio, city gate prices in 2005 were at $10.66/mcf.[80] By June of 2013, however, with the arrival of shale gas, national city-gate prices had dropped to $5.74/mcf ($4.47/mcf in Ohio). Fuel cell companies, having improved their efficiencies, and using low priced natural gas as fuel, began to produce power at competitive rates. By 2013 companies like Bloom Energy were producing power from fuel cells at around $0.08-0.10/kWh.[81] Indeed, such a price would have been competitive in Ohio in 2013 with net metering: the average retail price for electricity in Ohio in 2013 was $0.092/kWh.[82]

Yet the price of natural gas has continued to plunge since 2013, especially in the areas around the Appalachian basin, where pipeline constraint has caused regional hub prices to fall below the traditional Gulf Coast "Henry Hub" price. Prices in the Dominion Transmission Hub (western Pennsylvania) had dropped below the Henry Hub spot price by 2014.[83] By April 2015 the national average city-gate price had dropped to $3.91/mcf,

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[78] Solid Oxide fuel cells, for instance, can use the heat generated by the fuel cell to reform fuel (usually natural gas) into hydrogen. *See e.g.* http://www.bloomenergy.com/fuel-cell/solid-oxide-fuel-cell-animation/

[79] Long term in this sense means as much as five years, although hedging might allow for an even longer contract. The days of fixed price 20-year gas purchase contracts appear to be in the past, a casualty of protracted litigation in the 1990s. However gas producers have been actively looking to tie up markets for as much as five years since at least 2009. *See e.g.* B. Cassellman and R. Smith, "Energy Firms Think Long Term," *The Wall Street Journal*, December 30, 2009, found at: http://www.wsj.com/articles/SB10001424052748704134104574624491513755228

[80] http://www.eia.gov/dnav/ng/hist/n3050oh3a.htm.

[81] S. Curtin and J. Gangi, *The Business Case for Fuel Cells 2013*, at 18, http://www.fuelcells.org/pdfs/2013BusinessCaseforFuelCells.pdf. Clear Edge Power was also cited as producing power in this range. *Id.*

[82] http://www.eia.gov/electricity/state/ohio/.

[83] http://www.eia.gov/todayinenergy/detail.cfm?id=18391

and the average fuel cost for natural gas power units had dropped to $3.23/mcf.[84] Ohio city-gate and natural gas generation fuel prices (not yet posted in July 2015) should correspondingly be lower than the national averages, and continue to be so for near term, at least until new interstate pipelines come on line in 2017-2020.[85]

In 2013 natural gas prices were such that fuel cells running on natural gas were already becoming competitive. Since then, natural gas prices have dropped another 30%. This certainly bodes well for fuel cell generation running on natural gas. Moreover, prices look like they will continue to stay low. The EIA projects Henry Hub prices will still be under $6/mcf by 2030.[86] And new shale resources continue to found, as well as new says to make them economical to produce. A new report from West Virginia University recently reported that the Utica Shale contained "technically recoverable" reserves of 782 Trillion Cubic Feet (TCF).[87] Such reserves rival that for the Marcellus Shale, already one of the world's largest gas plays. In short, there is reason to expect prices will continue to be low for a while.

1. Spark Spread in Ohio

The spark spread is calculated based upon the conversion efficiency for natural gas-fired generation systems. It is used as a tool used by generation companies to identify the most profitable locations for building gas-fired generation. Spark spread is calculated using the following equation:

Spark spread ($/MWh) = power price ($/MWh) – [natural gas price ($/mmBtu) * heat rate (mmBtu/MWh)]

A key component of the spark spread is the efficiency of the generating unit. For purposes of calculating spark spreads, the EIA deploys an average efficiency of around 50%. This represents a conversion efficiency of around 7000 Btu/kWh, an efficiency that can be found in state-of-the-art combined cycle plants. Traditional gas-fired steam turbines will require between 10-15,000 Btu/kWh.[88] This will render a

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[84] http://www.eia.gov/dnav/ng/hist/n3050us3m.htm.
[85] "Several Pipeline Projects Are Underway," EIA October 24, 2014 (excel spreadsheet). *See also*: Natural Gas Infrastructure Implications of Increased Demand from the Electric Power Sector, U.S. Department of Energy, February 2015, found at:
http://energy.gov/sites/prod/files/2015/02/f19/DOE%20Report%20Natural%20Gas%20Infrastructure%20V_02-02.pdf
[86] http://www.eia.gov/forecasts/aeo/section_prices.cfm (reference case).
[87] *See e.g.* K. Boman, "Study: Utica Shale Larger Than Previous Estimates," *Rigzone*, July 16, 2015, http://www.rigzone.com/news/oil_gas/a/139667/Study_Utica_Shale_Larger_Than_Previous_Estimates. Technically recoverable reserves are not the same as commercially recoverable reserves. The Utica is deeper than the Marcellus, and therefore generally more expensive to produce. In 2012 the United States Geologic Survey previously had estimated reserves at around 38 TCF.
[88] *See* "An Introduction to Spark Spreads, " EIA, found at:
http://www.eia.gov/todayinenergy/detail.cfm?id=9911

smaller spark spread. Fuel cells, on the other hand, commonly have an efficiency ranging from 52-65%, which would lead to a higher spark spread.[89]

Spark spreads in the PJM regional transmission organization territory (which includes Ohio) are expected to reach record levels in 2015-2016.[90] In late July 2015, the Mid-Atlantic region (in PJM territory) recorded some of the highest spark spreads in the United States – at $47.90/MWh (second only to New York City, at $50.49).[91] This spread was driven by a natural gas trading price of $1.52/mmbtu – by far the lowest in the nation -- while wholesale electricity was trading on the wholesale exchanges at $58.56/MWh (i.e. $0.059/kWh).[92]

The low cost of natural in the PJM/Mid-Atantic region is being driven primarily by a constrained pipeline system and an oversupply of natural gas production from the Marcellus and Utica formations in Pennsylvania, Ohio and West Virginia. As can be seen from EIA data for July 29, 2015, natural gas prices in the Midwest and the Gulf Coast are considerably higher – between $2.91 to $2.93.[93]

Select Spot Prices for Delivery July 29, 2015

Region	**Natural Gas** ($/million Btu) **Price**	**Electricity** ($/MWh) **Price**	**Spark Spread** ($/MWh)
New England	3.37	51.75	28.19
New York City	3.02	71.62	50.49
Mid-Atlantic	1.52	58.56	47.90
Midwest	2.93	43.52	22.99
Louisiana	2.91	31.50	11.14
Houston	2.85	53.00	33.06
Southwest	2.83	36.00	16.21
Southern CA	3.04	44.52	23.27
Northern CA	3.27	41.67	18.80
Northwest	2.45	44.94	27.79

Table 1. Spark Spread for Various Regions in the United States, July 29, 2015
Source: Energy Information Agency

However the spark spread only speaks to the spread between natural gas and electricity generation costs – it does not take into account other costs that are passed through to end users, such as capacity, distribution and ancillary charges. Capacity charges are more or less a cost for PJM passes through to ratepayers to have back up

[89] *See* note 14, *supra*. GE has apparently achieved efficiency of 65%. *See e.g.* M. Kassner, "GE's New Fuel Cell Technology is a Came Changer," *TechRepublic*, August 5, 2014, found at: http://www.techrepublic.com/article/ges-new-fuel-cell-technology-is-a-game-changer/

[90] *See* "PJM to Hit Record Spark Spread in 2015-16," *RTO Insider*, April 14, 2015, found at: http://www.rtoinsider.com/pjm-natural-gas-spark-spreads-14294/

[91] http://www.eia.gov/todayinenergy/prices.cfm

[92] *Id.*

[93] *Id.*

power available on demand during high load periods, such as summer weekdays. It is set three years ahead by an auction managed by PJM.

Within the PJM footprint, capacity charges are by far the highest in northern Ohio. Ohio has several capacity zones, including the American Transmission Systems, Inc. (ATSI) zone. All zones experienced substantial capacity increases as a result of the auctions of 2012. However ATSI (operated by First Energy) experienced the highest cost increases: capacity costs rose by as much as $0.02/kWh in the ATSI region in 2015.[94] This area includes the distribution territories of Toledo Edison, Ohio Edison and Cleveland Electric Illuminating Company (and Pennsylvania Power).

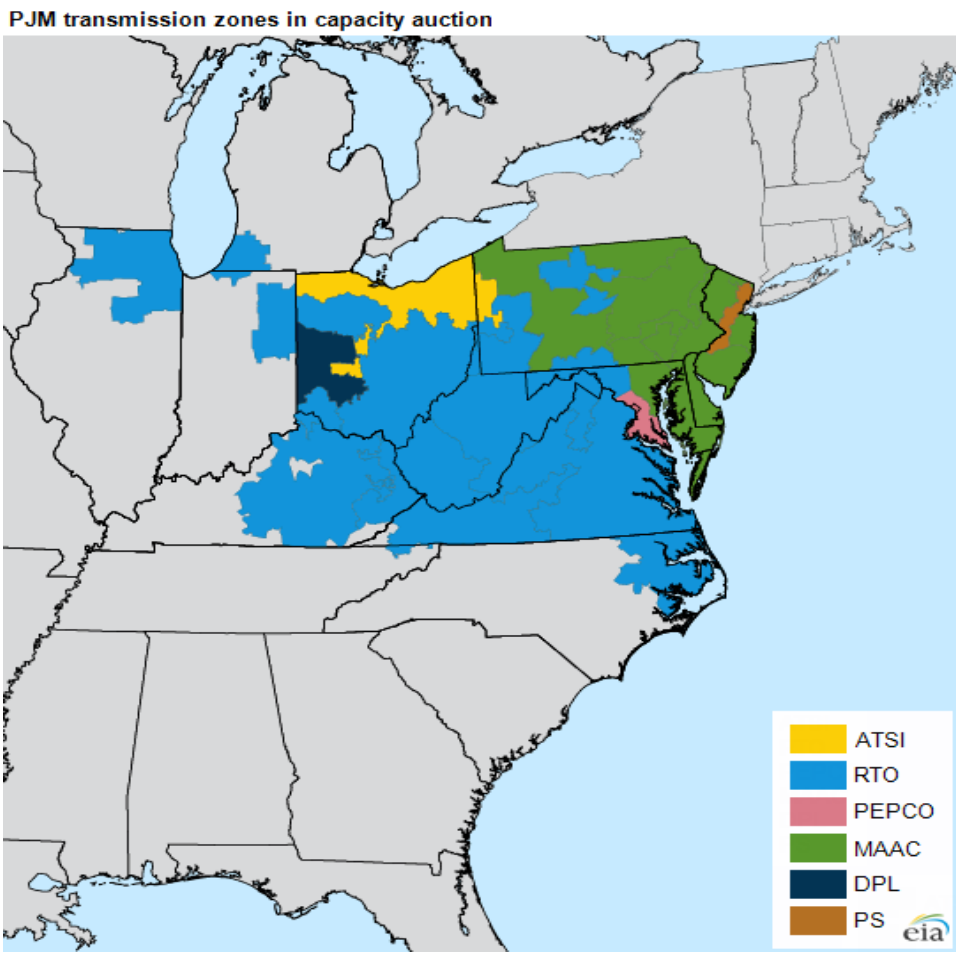

Figure 4: PJM Transmission Zones
Source: Energy Information Agency

So for at least northern Ohio in 2015, and for DG that is consumed on site, the record high spark spreads may be augmented by record high capacity charges, making the value proposition for fuel cell power generation even more compelling. It is, of course, speculative as to how long the historically large spark spreads and capacity charges will

[94] *See* Thomas, et al, "Understanding Ohio Electricity Markets," at 31, *supra* note 13.

be around; new pipelines are being built that will address in part the natural gas constraint problem, and capacity shortfalls are being addressed by importing capacity from other regional transmission organizations into Ohio. But we can reasonably expect that there will continue to be inexpensive natural gas supplies, large spark spreads and high capacity charges for the next five years or so in the Mid-Atlantic region – making natural gas based generation more attractive.

2. Natural Gas Pipeline and Processing Plants In Ohio

Ohio has seen in recent years the rapid development of natural gas midstream infrastructure build out. Five years ago, there were no natural gas processing facilities in Ohio, and the pipeline system largely consisted of interstate and distribution lines. Today, however, there are a number of new and planned gathering lines, processing plants, and new interstate pipelines. Further, the U.S. Department of Energy projects that the Marcellus/Utica region will have the most activity for pipeline development, with capital expenditures of between $10 billion and $40 billion by 2030.[95]

New infrastructure means new opportunities for long-term natural gas sales contracts, and therefore new power generation. Many of these facilities are also electricity-intensive – especially where processing, fractionation, cracking, refining or other chemical processes take place. Oil and gas producers, struggling with low prices, are in 2015 willing to enter into long-term limited warranty contracts to ensure markets are available for their natural gas production.

A fuel cell located at the tailgate of a cryogenic processing plant, for instance, might be a promising location. Producers could extract valuable natural gas liquids from the gas stream, and then sell a portion of the leftover gas to the midstream processing company, who uses it to generate electricity to support the processing activity. There are such processing plants located throughout Southeast Ohio today as a result of the rich hydrocarbon streams coming from the Utica. Likewise, new interstate lines are being built that run through northern Ohio, where the spark spread and capacity charges are high. Generation located along this corridor could be augmented by a low cost natural gas contract that results from being near an interstate line.

[95] "Natural Gas Infrastructure Implications of Increased Demand from the Electric Power Sector," p 27-28, U.S. Department of Energy, found at: http://energy.gov/sites/prod/files/2015/02/f19/DOE%20Report%20Natural%20Gas%20Infrastructure%20V_02-02.pdf

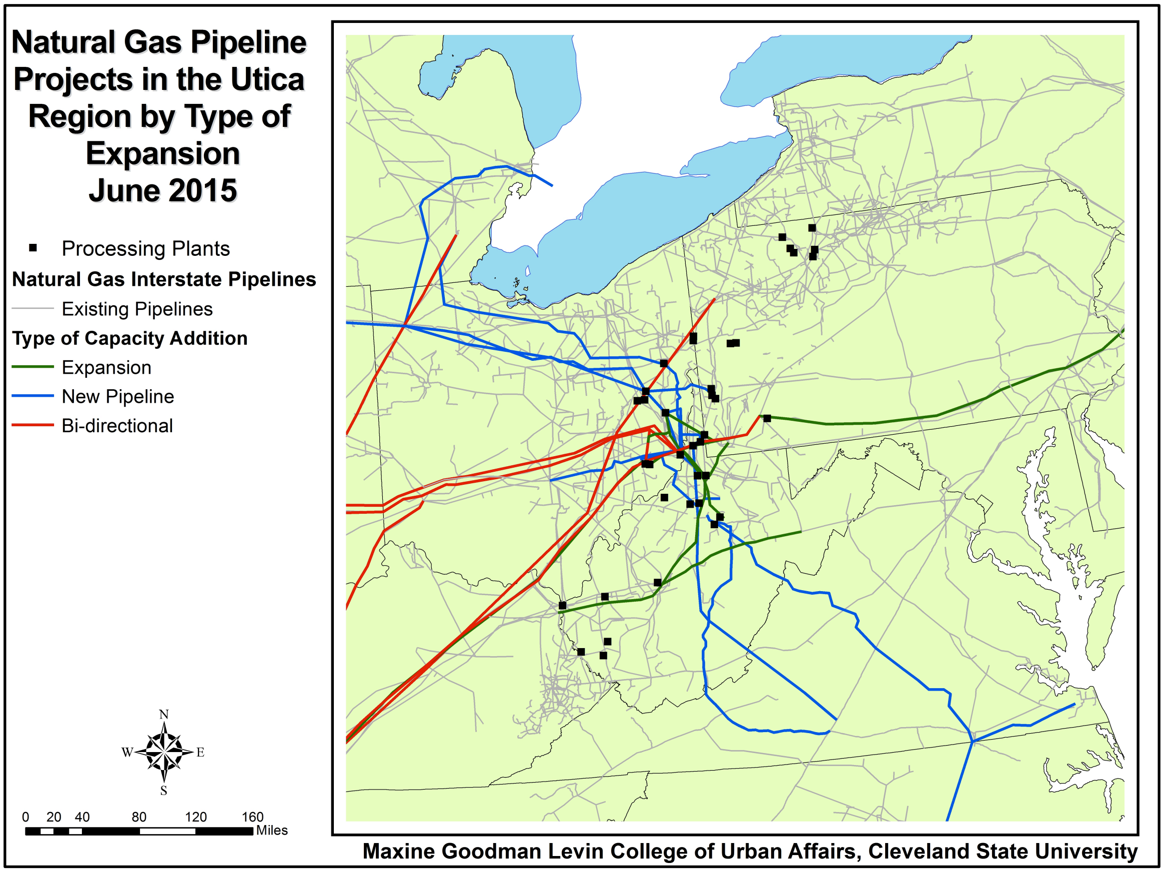

Figure 5. Location of Processing Plants and New Interstate Pipeline Projects, 2015
Source: Maxine Goodman Levin College of Urban Affairs

Long-term natural gas contracts were the source of much litigation in the 1980s and the 1990s. The financial risks of take-or-pay (outputs) and warranty (requirements) contracts had proven to be extremely problematic. These risks continue to plague capital investment into projects like power generation and chemical plants. Today, however, much of the risk can be mitigated through such financial tools as price indexing, hedges, price re-openers and similar strategies. In the end, however, the most leverage that a company looking to build generation will have in getting a firm long term natural gas sale contract (either quantity or price) will be at those locations where the producer can reduce its costs. These tend to be at gathering points, such as on pipeline systems or at processing plants.

B. Fuel Cells Using Hydrogen as Fuel

1. By-Product Hydrogen or Hydrogen Rich Waste Gas.

Fuel cells that operate directly on hydrogen – most notably PEM and phosphoric acid fuel cells – can and do have a place in stationary power generation. PAFC technology has been demonstrated by UTC Power (now Doosan) successfully in a number of locations, having performed reliably for long periods of time (although the UTC model included onboard processing). PEM cells also require hydrogen, and do not usually include onboard processing. While PEM cells are more commonly used for transportation, they have been used for stationary power production, usually in small-scale settings.[96] One exception to this is the First Energy/Ballard 1 MW peaking plant in Eastlake, Ohio.

The least expensive source of hydrogen for power generation comes as a byproduct of making chlorine (called chlor-alkali plants). Wherever chlorine is being manufactured in industrial amounts should be a potential candidate for locating fuel cells. Ohio, however, does not have many chlor-alkali facilities. ASHTA Chemicals has a plant in Ashtabula, Ohio, that formerly supported a 400 kW PAFC fuel cell demonstration module.[97] BleachTech, LLC, based in Seville, Ohio, another company that manufactures chlorine, may also have byproduct hydrogen available to support fuel cell demonstration.

Hydrogen is also available from coke oven and other industrial waste gas streams. However the technology to extract hydrogen from waste gas is still in research stages.[98] There are a number of coke oven facilities in Ohio. To date, most of the effort for recovering value from coke oven waste streams has related to waste heat recovery.[99]

2. Reformation of Natural Gas.

Byproduct gases can only provide limited opportunities for stationary fuel cells. Natural gas, on the other hand, is generally available in Ohio and throughout the United States. Since natural gas is the most common feedstock for hydrogen manufacturing, less expensive natural gas should lead to less expensive hydrogen.[100] For this reason much hydrogen manufacturing and transportation infrastructure has developed in the Louisiana and Texas Gulf Coast, where natural gas has historically been cheapest in the United States.

Yet feedstock costs are only a part of what goes into the acquisition cost of hydrogen: other factors include the cost of electricity, economies of scale in steam reforming, and transportation and storage costs. Praxair, for instance, recently expanded

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[96] J. Nail, G. Anderson, et al, "The Evolution of the PEM Stationary Fuel Cell in the U.S. Innovation System, presented at 2003 OEDC Conference, at 10, found at: http://www.oecd.org/science/inno/31967874.pdf.

[97] http://www.altenergymag.com/content.php?issue_number=08.04.01&article=fuelcells.

[98] See e.g. W.H. Chen, et al, "Hydrogen production from Steam Reforming Coke Oven Gas," 37 International Journal of Hydrogen Energy, Issue 16, August 2012 (Elsevier Publishing), found at: http://www.sciencedirect.com/science/article/pii/S0360319912011640.

[99] Heat recovery technologies have been demonstrated in locations like the FDS Coke Plant in Oregon and the SunCoke Energy facilities in Middletown and Franklin Furnace (Haverhill), Ohio. *See*: http://epa.ohio.gov/portals/27/transfer/ptiApplication/mcc/mcc_v3.pdf.

[100] It is not, however, the cleanest source of hydrogen. Use of biogas would offset most of the carbon emissions. There have been a number of biogas demonstrations, including some used in conjunction with wastewater treatment facilities. New York, for instance, has deployed a 200 kW phosphoric acid fuel cell demonstration run from biogas from a wastewater treatment facility in Yonkers. *See* P. Morini, "CHP Opportunities at Wastewater Treatment Plants." *Distributed Energy.* July/August 2004. Ohio of course has a number of wastewater treatment facilities.

its steam reforming capacity in Niagara Falls, where it benefits from low-cost and sustainable power generation produced from local hydroelectric turbines. It then ships the hydrogen by truck or rail to locations throughout the U.S. Northeast, Midwest and in southeastern Canada.[101]

2.1 Fuel Cells Running on Transported and Stored Hydrogen.

Fuel cells running on transported and stored hydrogen have begun to have success in the transportation markets, especially for continuously used vehicles, such as forklifts and buses. There is little doubt that shale gas has had a big impact on this sector: hydrogen gas, where available for refueling, is cost competitive with gasoline and diesel fuel. Hydrogen is often sold by its mass, measured in kilograms (kg). For purposes of comparing hydrogen to gasoline, 1 kg is roughly equivalent to 1 gallon of gasoline on an energy content basis. In 2014, when natural gas was selling for over $4/mmbtu, hydrogen gas cost around $1.80/kg to manufacture at a centralized location.[102] Adding another $3/kg for shipping, handling, transporting and storing hydrogen yields a retail price of around $4.70/kg.[103] This translates to a fuel cost of around 9.4 cents per mile for hydrogen compared to 14 cents per mile for gasoline (based on $3.50/gallon).[104]

Since 2014, natural gas prices have dropped further. The Henry Hub price for natural gas in June 2015 was $2.78. In the Appalachian region, spot prices were even lower. TCO Index pricing for June averaged $2.74, and the DTI Index posting was $1.41.[105] The result is that hydrogen steam reforming companies are able to get long term supplies of natural gas at low rates, and are in turn able to supply long-term contracts for delivery of hydrogen to locations throughout the Midwest and the Mid-Atlantic. Indeed, this is exactly the scenario that played out for the Stark Area Regional Transit Authority, when it was able to negotiate a long-term hydrogen contract for its fuel cell bus fleet at a cost of $4.59/kg.[106]

Stationary power generation, however, has a much lower profit threshold than does power for transportation. Nevertheless, what makes PEM cells valuable for transportation also makes them valuable for peak generation: they can be turned on and off easily. Peak power value depends upon the circumstances; during some peaking times, such as occurred during the polar vortex in the winter of 2014, prices can skyrocket. Duke Energy Ohio estimated the value of peak power in general in Ohio: in

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[101] *See* "Praxair Niagara Falls to Increase Hydrogen Production," April 3, 2014, http://www.praxair.com/news/2014/praxair-niagara-falls-to-increase-hydrogen-production.

[102] M. Kratochwill and A. Yang, "Shale Gas Could Drive Economics of Hydrogen Fuel Cell Vehicles, IHS Quarterly, November 6, 2014, found at: http://blog.ihs.com/q14-shale-gas-could-drive-economics-of-hydrogen-fuel-cell-vehicles.

[103] *Id. See also*, "Hydrogen Production Cost Analysis," http://www.nrel.gov/hydrogen/production_cost_analysis.html ($2.00/kg for compression, storage and dispensing costs).

[104] Kratochwill, et al. The authors developed the comparison based upon the Hyundai Tucson Fuel Cell Vehicle compared to the Hyundai Tucson SUV equipped with an internal combustion engine.

[105] Southeastern Ohio Oil and Gas Association Report, June 2015, found at: http://www.sooga.org/uploads/2015-06%20SOOGAgascommitteereportJune2015.pdf

[106] *See* footnote 20, *supra,* and accompanying text.

the summer of 2012, off peak rate plans ranged from $0.041 to $0.055/kWh, while peak rate electricity plans ranged from between $0.175 to $0.315/kWh – roughly 3 to 6 times the value of off peak power.[107] Peak generation periods were for five hours: 2 p.m. to 7 p.m.

At least one company is making PEM cells for distributed generation purposes -- offering intermittent, peak load support during times of high demand. Ballard's ClearGen fuel cell system offers a 1 MW peak loading capability.[108] This system is being demonstrated in Eastlake, Ohio by FirstEnergy.[109] Given the low cost of hydrogen and the relatively high cost of generating peak generation in Ohio in 2015, this test should provide valuable insight into the viability of stationary power generation from PEM cells.

2.2 Excess Reformation Capacity.

Another way to obtain inexpensive hydrogen is to locate the fuel cells at locations where there may be excess hydrogen reformation capacity. Generally speaking, such facilities are not common, and where they do exist, companies hope to exploit the excess capacity in the future for industrial uses. One location where excess capacity may exist is at the GE Tungsten Road facility in Euclid, Ohio, where a steam reformer exists. Oil refineries commonly include hydrogen refining on site, although in Ohio the refineries have used all available hydrogen in its process to break down heavy oil. Here shale may also have an effect; as lighter crude is brought into Ohio refineries, it is possible that the demand for hydrogen may diminish, leaving excess hydrogen manufacturing capacity.

At least one Ohio company is in the process of building more refining capacity: Marathon Petroleum Company. Marathon is adding about 25,000 bbls/day processing capacity in its Canton, Ohio facility.[110] This facility will be taking lighter crude from the Utica region, so it may not need to upgrade its hydrogen reforming capacity, but if it does, it could build excess capacity into its plans, making it a candidate for fuel cell power generation.

IV. Conclusions

Fuel cells have faced many obstacles to mainstream commercial adoption, including such things as durability, reliability and catalyst cost. But none has been more problematic for demonstration projects in Ohio than the cost of hydrogen. However shale gas promises to resolve cost problem. With the advances made in recent years in fuel cell technology, especially for solid oxide fuel cells, Ohio should revisit the value proposition provided by stationary power generation from fuel cells.

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[107] "Overview of Duke Energy Ohio's Experience with Time Differentiated Rates," May 24, 2012, found at: http://www.naruc.org/international/Documents/Time%20differentiated%20rates%20-%20Tim%20Duff%20Duke%20Energy.pdf

[108] http://www.ballard.com/fuel-cell-products/cleargen-multi-mw-systems.aspx.

[109] http://www.ballard.com/about-ballard/newsroom/news-releases/news11021001.aspx

[110] E. Pritchard, "Marathon to Invest at Canton Refinery," *Canton Repository*, December 5, 2013, found at: http://www.cantonrep.com/article/20131205/NEWS/131209656.

This should begin by looking at possible public/private funding partnerships. Ohio is in the process of developing new PACE funding opportunities, and other similar opportunities may be available for financing stationary fuel cells in Ohio. The spark spread in Ohio supports natural gas based power generation. Other factors, such as environmental issues and capacity charges, support fuel cell generation in distributed settings. With long term natural gas contracts with attractive terms becoming available, and with carbon regulation set to be part of the energy landscape, 2015-16 is a good time for Ohio energy, environmental and economic stakeholders to revisit the role fuel cells can play in power generation in Ohio.

About the Authors:

Andrew R. Thomas, J.D.
Andrew Thomas is an Executive in Residence at the Levin College of Urban Affairs, where he directs and conducts research for the Energy Policy Center, and is a member of the Ohio Bar. He can be reached at 216 687 9304 or at a.r.thomas99@csuiohio.edu

Benjamin Y. Clark, Ph.D.
Ben Clark is the executive director for the Great Lakes Environmental Finance Center in the Levin College of Urban Affairs, and is an Associate Professor in the College of Urban Affairs. He can be reached at 216 687 2497 or b.y.clark@csuohio.edu.

Allan Immonen, J.D.
Allan Immonen is a 2014 graduate of the Cleveland Marshall School of Law, and an intern for the Energy Policy Center. He is a member of the Ohio Bar.