2018
Hydrogen and Fuel Cell Development Plan

Rhode Island  Hydrogen Economy

Economic Development
Environmental Performance
Energy Reliability
Hydrogen and Fuel Cell Development Plan – “Roadmap” Collaborative

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Supporting Agencies
United States Small Business Administration

Cover Photo References
Wikipedia; “Portal: Rhode Island/Selected panorama 4;”

Wikimedia Commons; “Rhode Island State House;”


U.S. Navy; “USS Mahan prepares to pass under Rhode Island bridge;”

1 NEESC is funded through a contract with the U.S. Small Business Administration
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EXECUTIVE SUMMARY

Existing businesses and institutions in Rhode Island have the potential to install 52 megawatts (MW) of electric generation using fuel cell technology, which would have an annual output of approximately 438,000 megawatt hours (MWhs). This amount of fuel cell generation capacity can reduce emissions of nitrogen oxides (NOx) emissions by approximately 30 metric tons annually.

Zero emission fuel cell electric vehicles (FCEV) could replace existing conventional vehicles in Rhode Island, starting with 185 vehicles, which could reduce annual carbon dioxide (CO2) emissions by approximately 2,050 metric tons and NOx emissions by 0.7 metric tons. Additionally, fuel cells could provide a zero emission alternative for forklifts and other material handling equipment at warehouse facilities, airports, and other emission constrained areas.

While the installation/deployment of fuel cells may be technically viable at many locations, this plan focuses on hydrogen and fuel cell applications that may be both technically and economically viable. The Northeast Electrochemical Energy Storage Cluster (NEESC) recommends development of the following market opportunities for stationary power, vehicles, and supporting hydrogen infrastructure to meet economic, environmental, and energy needs:

- 52 MW fuel cell electric generation capacity;
- 185 FCEVs (171 passenger vehicles and 14 transit/paratransit buses) as zero emission vehicles (ZEV); and
- One to two hydrogen refueling stations (to support FCEV/FCEB deployment).

Locations where fuel cell installations may be both technically and economically viable include a wide range of private, state, and federal buildings used for offices, manufacturing, data management, warehousing, large retail, education, food sales and services, lodging, in-patient healthcare, and public order and safety. Similarly, fuel cell installations may also be viable at wastewater treatment plants, landfills, telecommunications sites, seaports, high-traffic airports, and for electric grid service. Locations for FCEVs and hydrogen refueling would be technically and economically viable in areas of the state where fleets, early market adopters, and hydrogen users co-exist.

Based on a 2017 IMPLAN economic analysis, Rhode Island’s hydrogen and fuel cell supply chain contributed to the region’s economy by providing:

- approximately **$13 million in revenue and investment**;
- more than **51 indirect and induced jobs**;
- over **$509,000 in state and local tax revenue**; and
- over **$3.5 million in labor income**.

The deployment of hydrogen and fuel cell technology will reduce the state’s dependency on oil; improve air and water quality; help meet carbon and ZEV requirements; utilize renewable energy from indigenous sources such as biomass, wind, and photovoltaic (PV) power; and increase the number of energy sector jobs within the state. This plan provides links to relevant information to assess, plan, and initiate hydrogen and/or fuel cell deployment to help meet the energy, economic, and environmental goals for the state of Rhode Island.

Policies and incentives that support hydrogen and fuel cell technology will increase deployment. Increased deployment of hydrogen and fuel cell technology will increase production and create jobs throughout the supply chain. As deployment increases, manufacturing costs will decline and hydrogen and fuel cell technology will be in a position to compete more effectively in a global market without incentives. Policies and incentives can be coordinated regionally to maintain the regional cluster as a global exporter for long-term growth and economic development.
INTRODUCTION

A Hydrogen and Fuel Cell Development Plan was created for each state in the Northeast region (Rhode Island, Vermont, New Hampshire, New Jersey, Connecticut, Maine, New York, and Massachusetts), with support from the United States (U.S.) Small Business Administration (SBA), to increase awareness and facilitate the deployment of hydrogen and fuel cell technology. The intent of this guidance document is to make available information regarding the economic value and deployment opportunities to increase environmental performance and energy reliability using hydrogen and fuel cell technologies made by businesses in the region.

Technology Description

A fuel cell is a device that uses, but does not burn, hydrogen (or a hydrogen-rich fuel such as domestic natural gas) and oxygen to create an electric current. Fuel cells occupy a technology platform that when coupled with electric drivetrains have the potential to replace the internal combustion engine (ICE) in vehicles and provide power for stationary and portable power applications. Fuel cells are in commercial service throughout the world, providing thermal energy and electricity to power the grid, homes, and businesses. Fuel cells are also used in vehicles, such as forklifts, automobiles, trucks, buses, and other land, marine, air, and space equipment. Fuel cells for portable applications currently in development will provide power for video cameras, military electronics, laptop computers, and cell phones.

Figure 1 – Hydrogen Production

Hydrogen can be produced using a wide variety of resources found here in the U.S. Hydrogen can be renewable and produced by waste, biomass, wind, and solar. Production technology includes electrolysis of water, steam reforming of natural gas, coal gasification, thermochemical production, and biological gasification (see Figure 1).²

Natural gas, which is composed of four (4) hydrogen atoms and one (1) carbon atom (CH₄), has the highest hydrogen-to-carbon ratio of any energy source. Furthermore, natural gas is widely available throughout the Northeast region, is relatively inexpensive, and is primarily a domestic energy supply. Consequently, natural gas shows potential to serve as a transitional fuel for the near future hydrogen economy. Over the long term, hydrogen production from natural gas may be augmented with renewable energy, nuclear, coal (with carbon capture and storage), and other low-carbon domestic energy resources.³

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Industry/Market Status

Demand for hydrogen and fuel cell systems have increased as the cost of the technologies has come down and awareness of their economic and environmental benefits has grown. This in turn has led to steady growth in the hydrogen and fuel cell industry in the U.S., with large and small companies located across the country. States and local governments are also recognizing the advantages of hydrogen and fuel cell technology in providing energy resilience, reduced emissions, improved air quality, and economic growth. Many states have established policies to promote the adoption of hydrogen and fuel cell technologies and/or initiated collaborative efforts to accelerate adoption.

Stationary fuel cells are providing stable power and heat around the world in microgrids and at wastewater treatment plants, food and beverage plants, office buildings, telecommunication hubs, data centers, retail stores, universities, hospitals, hotels, government facilities, and other applications. On the utility side of the meter, large-scale fuel cell systems are being deployed to support the electric grid where transmission is constrained or increased reliability is sought. These fuel cell systems are providing clean 24/7 power generation to complement the increasing deployment of intermittent solar and wind resources and support grid reliability.

Transportation applications include motive power for passenger cars, buses, other fuel cell electric vehicles (FCEVs), specialty vehicles, material handling equipment, and auxiliary power units for off-road vehicles. Early market adopters of these light duty FCEVs may include fleet operators. As hydrogen fueling infrastructure expands, FCEVs will begin to gain greater market acceptance, resulting in faster market penetration. In the year 2032, over 5 million of these vehicles are expected to be sold with projected revenues of over $250 billion.4

Drivers

Economic benefits, environmental quality, and energy reliability are driving the development of hydrogen and fuel cell technologies for regional, national, and global markets. Federal research and tax incentives have been important drivers for developing FCEVs, hydrogen infrastructure, and fuel cell stationary power generation.

The age distribution of hydrogen and fuel cell companies in the Northeast states suggests a substantial expansion in the sector, with several small businesses exhibiting recent growth. Growth of hydrogen and fuel cell patents in the Northeast far exceeds the growth of all types of clean energy patents in the region. The proximity of the original equipment manufacturers (OEM) and supply chain companies in this cluster has provided a competitive advantage for research, design, development, manufacturing, and export of commercial products to national and international markets.

Energy Resiliency

Extreme weather events in the Northeast, including Hurricane Irene (2011), the Nor’easter snowstorm (2011), Superstorm Sandy (2012), Blizzard Nemo (2013), and the “bomb cyclone” (2018) have emphasized the need for clean and reliable distributed generation located at mission critical facilities to maintain power when grid power is not available due to the impacts of severe weather. Rhode Island was significantly impacted by Tropical Storm Irene, which curtailed power to 297,000 customers.5 Six weeks later, Superstorm Sandy left more than 116,000 customers without power in Rhode Island.6 In several Northeastern states, where powerful

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5 “RI wakes up to ‘catastrophic’ power outages”, Deseret News, Associated Press; August 29, 2011.
storms and inclement weather have impacted the electrical grid, fuel cells are now being considered as ultra-clean generators for essential services, first responders, refueling stations, and emergency shelters.

More than 25 fuel cells, located in the Northeast region affected by Hurricane Sandy, performed as expected and provided electricity, heat, and hot water during and after the storm passed. Several states are considering initiatives that include increased use of performance and engineering standards, improved planning, hardening of the infrastructure, increased communications and collaboration, additional response training, and the use of microgrids and other emerging technologies to mitigate impact(s) on the energy grid infrastructure.

**Economic Impact**

The Northeast hydrogen and fuel cell industry, while still emerging, has contributed:

- Over $1.4 billion in revenue and investment;
- More than 6,620 direct, indirect and induced jobs; and
- Labor income of approximately $615 million.

Rhode Island benefits from indirect and induced employment and revenue from this industry. Furthermore, Rhode Island has a definitive and attractive economic development opportunity to greatly increase its participation in the hydrogen and fuel cell industry as this collective industry strives to meet global demand for clean, low carbon heat and power. Rhode Island’s renewable energy production initiatives could be further enhanced with energy storage provided by hydrogen. These drivers will become more important as users turn to sustainable energy sources in place of fossil fuels.

**Table 1 - Rhode Island Economic Data – Hydrogen Fuel Cell Industry**

<table>
<thead>
<tr>
<th>Supply Chain Members</th>
<th>Rhode Island Economic Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18+</td>
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<tr>
<td>State/Local Tax ($M)</td>
<td>.509</td>
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<tr>
<td>Indirect Revenue and Investment ($M)</td>
<td>9.6</td>
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<tr>
<td>Indirect Jobs</td>
<td>30</td>
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<tr>
<td>Indirect Labor Income ($M)</td>
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<tr>
<td>Induced Revenue and Investment ($M)</td>
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<tr>
<td>Induced Jobs</td>
<td>21</td>
</tr>
<tr>
<td>Induced Labor Income ($M)</td>
<td>1.1</td>
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<tr>
<td>Total Revenue and Investment ($M)</td>
<td>12.8</td>
</tr>
<tr>
<td>Total Jobs</td>
<td>51</td>
</tr>
<tr>
<td>Total Labor Income ($M)</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Rhode Island’s hydrogen and fuel cell supply chain companies realized approximately $13 million in revenue and investment in 2016. These companies are involved in the supplying of fuel, components, materials, equipment, and consulting/financial services. Furthermore, the hydrogen and fuel cell supply chain is estimated to have contributed approximately $3.5 million in labor income and over $509,000 in state and local tax revenue. Table 1 shows the economic impact of Rhode Island’s hydrogen and fuel cell supply chain.

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7 Economic impact derived from an IMPLAN Economic Financial Model, Todd Gabe; NEESC; September 2017. This analysis assesses the direct, indirect, and induced values of the Northeast region’s hydrogen and fuel cell supply chain using 2016 and 2017 data.

8 Indirect impacts are the estimated output (i.e., revenue), employment and labor income in other business (i.e., not OEMs) that are associated with the purchases made by hydrogen and fuel cell OEMs, as well as other companies in the sector’s supply chain. Induced impacts are the estimated output, employment and labor income in other businesses (i.e., non OEMs) that are associated with the purchases by workers related to the hydrogen and fuel cell industry.

Environmental Benefits
The combustion of fossil fuels for electricity production and motor vehicles are significant sources of NOx and CO2 emissions. In the stationary sector, the development of 52 MWs of fuel cell generation capacity in Rhode Island would reduce NOx emissions by approximately 30 metric tons annually. In the transportation sector, zero-emission FCEVs could replace existing conventional vehicles in Rhode Island, starting with 185 fleet vehicles, reducing annual CO2 emissions by approximately 2,000 metric tons and NOx emissions by 0.70 metric tons.10 The reduction of these emissions through the use of fuel cell technology would improve air quality, reduce health problems, reduce carbon emissions that contribute to climate change, and help to meet National Ambient Air Quality Standards.

FUEL CELLS FOR STATIONARY POWER

In 2016, combined retail sales of electricity in Rhode Island amounted to approximately 7.5 million megawatt-hours (MWh) for the residential, industrial, transportation and commercial sectors.11 New England’s annual electricity use is expected to be flat or decline slightly over the next decade under average conditions, with only a slight increase under extreme summer weather conditions. However, demand for new electric capacity is expected due in part to the replacement of older, less efficient generation facilities.12

Distributed Generation/Combined Heat and Power
Fuel cell technology has high value and opportunity (see Table 2) to help meet the projected increase in demand and need for new generation capacity with clean and high efficiency distributed generation (DG) located directly at the customer’s site. DG and energy storage will increase efficiency, improve end user reliability, and reduce emissions. This technology can also provide opportunities to maximize the efficiency and cost effectiveness of fuel cells with combined heat and power (CHP) applications. The use of CHP helps increase the efficiency of on-site energy use by recycling waste thermal energy for many end use applications, including hot or chilled water, space conditioning, and process heat. There is also an opportunity for tri-generation to simultaneously produce heat, power, and hydrogen for storage and/or transportation. It is estimated that approximately 100 MW of CHP installations currently exist in Rhode Island with a goal to increase this to 400 MW of in-state CHP by 2035.13 There are significant market opportunities for fuel cells with CHP, including development at schools, hospitals, energy intensive industries, and other critical facilities (see Table 3).

Grid Power
Fuel cells have a high capacity factor and can be used for grid power with direct ties to transmission and distribution systems. Applications include utility ownership for transmission and distribution reliability via voltage support, frequency regulation, and capacitance. In deregulated states, such as Rhode Island, legislation

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10 Assumes passenger car tailpipe emissions of CO2 are reduced by 4.67 metric tons CO2E/vehicle/year; transit bus emissions of CO2 are reduced by 89.27 metric tons CO2E/vehicle/year; NOx emissions for passenger vehicles at .213 g/mile x 11,443 and .59 g/mile x 34,000 for diesel fuel transit buses. https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.
11 U.S. EIA; “Table 1. 2016 Summary statistics (Rhode Island)”: Total retail sales (megawatthours); https://www.eia.gov/electricity/state/rhodeisland/; January 2018.
may be needed to allow utilities to acquire new fuel cell capacity for the purpose of providing distribution system benefits and enhancing distribution system reliability.14

Deployment

Based on a subset of targets identified within this Plan, there is the potential to develop 52 MW of stationary fuel cell generation capacity in Rhode Island, which would provide the following benefits (see Appendix V), annually:

- **Production of approximately 438,000 MWh of electricity.**15
- **Production of approximately 953,000 MMBTUs of thermal energy.**16
- **Reduction of NOx emissions by up to approximately 34 metric tons (electric generation only).**17

Resources necessary for this deployment may be offset by the following energy products: electricity, thermal energy, and possibly hydrogen. These energy products are of high value to end users for private power; utilities for grid power, voltage support, frequency regulation, and energy storage; and the State of Rhode Island for emergency power at critical facilities.

This Plan focuses primarily on applications for 1) small fuel cells that are less than 200 kW, (typically 100 to 200 kW); 2) midsize fuel cells (typically 400 kW to 1,000 kW); and 3) large fuel cells (typically over 1 MW). Midsize and large fuel cells (>400 kW) are potentially viable for large energy users and grid applications, while small fuel cells (<200 kW) are potentially viable for site-specific applications, such as back-up power for telecommunications sites and grid resilience. Potential stationary targets are illustrated in APPENDIX I – Figure 1, “Rhode Island: Market Potential for Hydrogen and Fuel Cell Stationary Applications.”

**FUEL CELLS FOR TRANSPORTATION**

Government and industry are now investigating the use of hydrogen and renewable energy as a replacement of hydrocarbon fuels in the transportation sector, which accounts for 30.3 percent of Rhode Island’s total energy consumption.18 FCEVs have several advantages over conventional vehicles (see Table 4) and can reduce price volatility, decrease dependence on oil, improve environmental performance, and provide greater efficiencies. Targets for FCEV deployment and hydrogen infrastructure development include public/private fleets, bus transit, and specialty vehicles (see Table 5). Zero emission FCEVs could replace existing conventional fleet vehicles in Rhode Island, starting with 171 passenger vehicles 19, providing annual carbon dioxide (CO₂) emission reductions of approximately 800 metric tons and NOx emission reductions of approximately 0.4 metric tons. Additionally, the introduction of 14 zero emission fuel cell electric buses (FCEBs) in Rhode Island could

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16 MMBTU calculations are based on 400 kW PAFC and 1.4 MW MCFC units because SOFC units are non-CHP.
19 Analyses conducted by the Connecticut Center for Advanced Technology (CCAT) based on the ZEV eight-state MOU and HIS Automotive 2016 data for ME, VT, RI, MA, CT, NJ, and MD.
reduce annual CO₂ emissions by approximately 1,250 metric tons and NOₓ emission by approximately 0.3 metric tons.

Automakers are now making plans to comply with a ZEV program, which is modeled after the California ZEV Action Plan. Eight (8) states have committed and signed a Memorandum of Understanding (MOU) requiring large-volume automakers to sell approximately 3.3 million ZEVs between 2018 and 2025; 1.24 million of which are defined as “Electric and/or Hydrogen Fuel Cells” with the remainder being plug-in hybrid electric vehicles (PHEV). As one of the eight states that has signed the MOU, Rhode Island has the potential of deploying as many as 6,166 FCEVs by 2025 (See APPENDIX II – Eight (8) State MOU Projections for FCEVs).

**Light/Medium Duty Vehicle Fleets**

There are over 3,650 passenger fleet vehicles classified as non-leasing or company owned vehicles in Rhode Island. Passenger vehicles at transportation hubs for fleets are good candidates for hydrogen fueling and the use of FCEVs because they mostly operate on fixed routes or within fixed districts and can be fueled from a centralized station. As illustrated in Appendix I – Figure 2, “Rhode Island: Market Potential for Hydrogen and Fuel Cell Transportation Applications,” clusters of fleet vehicles in Rhode Island are located primarily in the Providence and Warwick areas.

**Bus Transit**

There are approximately 291 transit buses that provide public transportation services in Rhode Island. Although the efficiency of conventional diesel buses has increased, these vehicles have the greatest potential for energy savings by using high efficiency fuel cells. FCEBs have an average fuel economy of approximately 7.9 miles per kilogram of hydrogen, which equates to approximately 7 miles per diesel gallon equivalent (DGE). The average fuel efficiency of conventional diesel transit buses is approximately 3.87 miles per gallon. The use of hydrogen has the potential to reduce diesel fuel use by approximately 8,800 gallons of diesel fuel per vehicle, per year. The use of FCEBs may require: 1) fueling infrastructure to be co-located with the FCEB storage facilities, 2) redundancy of fuel supply, 3) generally accepted fuel measurements & certifications, and 4) an established track record for up-time performance.

**Specialty Vehicles**

Specialty vehicles, such as material handling equipment, airport tugs, street sweepers, and wheel loaders are used by a variety of industries, including manufacturing, construction, mining, agriculture, food sales, retailers, and wholesalers. Batteries that currently power some equipment for indoor use are heavy and take up significant storage space while only providing up to six hours of run time. Fuel cell powered equipment has zero emissions, a lower annual cost of ownership, and almost twice the estimated product life than battery powered equipment. Fuel cell powered lift trucks can be operated indoors, can operate up to eight hours before refueling, can be refueled quickly (2-3 minutes), and eliminate the need for battery storage and charging rooms (see Table 6).

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21 Vehicle Fleet data provided by IHS Automotive for CT, ME, MA, RI, NJ, MD (2016).
24 CARB Cost Assumptions and Data Sources (updated on 6/26/2017); https://arb.ca.gov/msprog/ict/meeting/mt170626/170626costdatasources.xlsx.
25 Assumes an average transit bus travels approximately 34,000 miles annually and 3.87 miles/gallon. http://www.afdc.energy.gov/data/10309. Calculated based on 10,160 grams CO₂ per gallon for diesel fuel.
Fuel cell powered material handling equipment is already in use at dozens of warehouses, distribution centers, and manufacturing plants in North America. For example, FreezPak Logistics has selected Plug Power's full-service GenKey solution for its new cold storage distribution center freezer warehouse under construction in Carteret, New Jersey. This GenKey deployment includes 25 fuel cell powered lift trucks, an outdoor hydrogen storage facility with two indoor dispensers, and total service for both the Fuel cell powered lift trucks and hydrogen storage system. Large corporations that are currently using or planning to use fuel cell powered material handling equipment across the country include: Central Grocers, FedEx Freight, Sysco Foods, Amazon, and Walmart.

**Hydrogen Infrastructure**

Hydrogen refueling infrastructure, consisting of production or delivery, storage, and dispensing equipment, is required to support FCEVs, including light duty passenger vehicles, buses and material handling equipment. While costs for hydrogen refueling infrastructure typically range from $1,000,000 - $3,260,000 per station, it is possible that construction of these stations could be backed by private sector financing or developed publicly in conjunction with deployment of high efficiency ZEV fleets. For example, Air Liquide is currently constructing hydrogen fueling stations in the Northeast, including Providence, RI and nearby Braintree and Mansfield, MA to support the initial deployment of FCEVs in high population density areas.

Models for hydrogen infrastructure financing have been developed, which support plans for deployment of FCEVs, by OEMs, state stakeholders, H2USA, and Northeast States for Coordinated Air Use Management (NESCAUM). This plan complements those efforts to help coordinate the initial development of hydrogen refueling infrastructure to improve the value of FCEVs to customers that will enable growth and distribution of ZEV technology into the market place. Potential sites for development include existing conventional refueling stations and new sites where hydrogen may be offered with other alternative fuels (see Table 7). Potential locations for hydrogen refueling infrastructure with fleet clusters, early market adopters, and other factors are identified in APPENDIX I – Figure 2, “Rhode Island: Market Potential for Hydrogen and Fuel Cell Transportation Applications”.

**Deployment**

A state investment of $1.48 million to $3.69 million for infrastructure development and FCEV deployment could provide a solid framework to support 171 passenger FCEVs and the development of up to seven hydrogen refueling stations. An additional $2.8 million (20 percent of $14 million) would be needed for the acquisition of 14 transit/paratransit buses.

- **171 Fuel Cell Electric Passenger Vehicles (20 FCEVs for RI State fleet) - $427,500.**
- **H2 Infrastructure (two stations) - $1 million to $3.26 million (50 percent of capital cost).**
- **14 Fuel Cell Transit/Paratransit Buses - $2.8 million (20 percent state cost-share/80 percent federal cost share).**

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28 California Air Resources Board; Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California; December 2013; CEC-600-2015-016.
30 It is projected that an order for 40 fuel cell buses would reduce the cost to $1 million or less. Rhode Island could utilize mechanisms such as group purchasing with other states to realize cost savings associated with a large order. NREL, Fuel Cell Buses in U.S. Transit Fleets: Current Status 2017; https://www.nrel.gov/docs/fy18osti/70075.pdf.
Funding for this investment will come from the private sector, federal and state resources\textsuperscript{31}, and from other sources, potentially including the VW Partial Consent Decree. The VW Partial Consent Decree has allocated approximately $13.5 million to Rhode Island for transportation that includes engine repowering, and alternative fueling with hydrogen.\textsuperscript{32}

**POLICY**

Rhode Island’s proximity to major load centers, cost of electricity, concerns over energy reliability and air quality have resulted in renewed interest in the development of efficient and cost effective renewable energy and energy storage technologies. Specific policies in Rhode Island supporting the hydrogen and fuel cell industry are displayed in Table 8 and Appendix IV – State Energy Policy/Incentives for Stationary Fuel Cell and Hydrogen Transportation.

Legislation and policy to support distributed generation and renewable technologies can be cost effective and appropriate for public investment. During the past decade, Rhode Island has made significant changes to increase the development and use of renewables, including the Renewable Energy Standard (RES), the Long-Term Contracting Standard for Renewable Energy (LTC), the Distributed Generation Standard Contracts Program, Net Metering, the Renewable Energy Growth Program (REG), and the Renewable Energy Fund (REF). The RES sets a statewide target of 16 percent renewable energy by 2019. Eligible renewable energy resources include solar, wind, wave, geothermal, small hydropower, biomass, and fuel cells operating on renewable fuels.\textsuperscript{33}

**Consistency with Energy 2035: Rhode Island State Energy Plan\textsuperscript{17}**

Energy 2035, Rhode Island’s State Energy Plan updates the State Guide Plan adopted in 2002. The State Energy Plan sets goals and policies to improve energy security, cost-effectiveness, and sustainability in all sectors of energy production and consumption. The use of hydrogen and fuel cell technology in Rhode Island provides clean, reliable power for transportation and stationary applications, and is consistent with several of the goals identified in Rhode Island’s State Energy Plan to secure a cost-effective and sustainable energy future by increasing fuel diversity, producing net economic benefits, and reducing greenhouse gas (GHG) emissions by 45 percent by the year 2035. To accomplish these goals, Rhode Island’s State Energy Plan calls for an “all of the above” approach for policies and initiatives to:

- Maximize energy efficiency in all sectors;
- Promote local and regional renewable energy;
- Develop markets for alternative thermal and transportation fuels, including promoting alternative fuel and electric vehicles;
- Make strategic investments in energy infrastructure;

\textsuperscript{31} The Federal Transit Administration’s Bus & Bus Facilities Infrastructure Investment Program could provide states and direct recipients 80 percent of the net capital project costs to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities including technological changes or innovations to modify low or no emission vehicles or facilities.


\textsuperscript{34} Energy 2035: Rhode Island State Energy Plan, October 8, 2015.
• Mobilize capital and reduce costs;
• Reduce greenhouse gas emissions; and
• Lead by example.

CONCLUSION

Hydrogen and fuel cell technology provides significant opportunities for more efficient use of cleaner energy, job creation and economic development. Realizing approximately $13 million in revenue and investment in 2016, the hydrogen and fuel cell industry supply chain in Rhode Island is estimated to have contributed over $509,000 in state and local tax revenue. If newer/emerging hydrogen and fuel cell technology were to gain momentum, the number of companies and employment for the industry could grow substantially. Hydrogen and fuel cell technology provides an opportunity for Rhode Island to more fully utilize its renewable energy industry using hydrogen and fuel cells for transportation, energy storage, and electric generation at consumer sites. Such use could maintain Rhode Island’s role as a showcase for regionally manufactured energy storage and renewable energy while reducing NOx and CO₂ emissions as new jobs are created. This configuration will also increase local end user reliability which is of high value for businesses and industry. To facilitate the execution of this Plan, Rhode Island will need to consider policies and initiatives for funding, financing, a schedule for goal implementation, and work responsibilities (Appendix IV – State Energy Policy/Incentives for Stationary Fuel Cells and Hydrogen Transportation). In addition, provisions for classifying fuel cells using any fuel as a renewable energy resource could make significant strides in increasing fuel cell deployment to help meet Rhode Island’s goals for increased efficiency, renewable energy, and CHP development. The near term market opportunities identified by NEESC include:

• 52 MW fuel cell electric generation capacity;
• 185 FCEVs (171 passenger and 14 transit/paratransit buses) as zero emission vehicles (ZEV); and
• One to two hydrogen refueling stations (to support FCEV deployment).

These market opportunities represent a short-term investment for long-term US productivity. As such, any provisions for funding/financing and schedule for implementation should recognize the short-term cost to facilitate long-term market opportunities. Development of infrastructure will require planning and investments by public and private entities with an expectation of a payback on those investments.
APPENDICES
APPENDIX I – Figure 1, Rhode Island: Market Potential for Hydrogen and Fuel Cell Stationary Applications

Rhode Island: Market Potential for Hydrogen and Fuel Cell Stationary Applications

Legend
- Military
- Port
- Commercial Airport
- Healthcare & Lodging
- Government Owned Building
- Public Order & Safety
- Education
- Food Sales & Service
- Large Retailer
- WWTPs & Landfill
- Energy Intensive Industry
- Area Served by Natural Gas

NEEEC is funded through a contract with the U.S. Small Business Administration (SBA)

Sources:
U.S. Census Bureau
U.S. General Services Administration
U.S. National Aeronautics & Space Administration
WorldwideMap
Replmap.com USA
Federal Aviation Administration
Natural Gas Association
Gasbinder.com
Federal Communications Commission
New England Natural Gas Association
Wikipedia.org
Data.gov
militarybases.com
newenglandgas.com
BingMaps.com
WPAirports.com
Federal Bureau of Prisons

March 22, 2017

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Appendix I – Figure 2, Rhode Island: Market Potential for Hydrogen and Fuel Cell Transportation

Rhode Island: Market Potential for Hydrogen and Fuel Cell Transportation Applications

Legend
- Fleet Owner Locations
- Interstates
- 30% or more of Households with income $200,000 or more
- Fleet Cluster (with # of fleet vehicles)

Fleet Vehicle Density
- High
- Low

NEESG is funded through a contract with the U.S. Small Business Administration (SBA)

Sources:
- PBS Automotive
- U.S. Census Bureau

The fleet vehicle counts are based on companies with a total of 20 or more passenger vehicles registered with the Rhode Island Department of Revenue. Companies with less than 20 vehicles are not depicted. Sales and leased vehicles have been included. Counts for vehicles registered in Rhode Island have been produced with the cooperation of the RIJUS and support provided by the U.S. SBA.

Disclaimer:
Information presented in this map is for planning purposes only. Verification of fleet locations and vehicle counts has not been undertaken or accomodative basis. No warranties, as to the accuracy of the data depicted, is implied.
### APPENDIX II – Eight (8) State MOU Projections for FCEVs

#### Eight (8) State MOU Total Sale Requirements Total ZEV Sales Requirements FCEV

<table>
<thead>
<tr>
<th>Year</th>
<th>CA</th>
<th>CT</th>
<th>MA</th>
<th>NY</th>
<th>RI</th>
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#### Projections for FCEVs per each MOU State

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<th>MA</th>
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<th>RI</th>
<th>VT</th>
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<td>6,584</td>
<td>592</td>
<td>321</td>
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<td>682</td>
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<td>17,208</td>
<td>24,404</td>
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34 Data provided is an averaged projection that does not account for different market drivers and/or incentives/barriers that could substantially change the deployment ratios between state and the delivery of different ZEV/hybrid vehicles.

35 Derived from applying 4.675 percent to FCEVs. The 4.675 percent was calculated by comparing 8-State MOU data to 2011 registered vehicles by state. These projections for FCEVs assumes 25 percent of all ZEVs (FCEVs and BEVs).

36 This data assumes 25 percent of all ZEVs (FCEVs and BEVs) will be FCEVs.


38 Derived from a DOE projection of California ZEV (FCEV and BEV), California transitional ZEV (plug-in hybrids), and California total sales (ZEV and transitional). These projections were applied to the other seven (7) states’ 2011 registered vehicle data to estimate potential ZEV vehicle requirements.

APPENDIX III – Rhode Island SWOT Analysis

Environment factors internal/external to Rhode Island’s existing hydrogen and fuel cell industry are provided below in the form of an economic strengths, weaknesses, opportunities and threats (SWOT) assessment. The SWOT analysis provides information helpful in matching the industry’s resources and capabilities to the competitive environment in which it operates.

Strengths
- **Stationary Power** – Strong market drivers (electric cost, environmental factors, critical power).
- **Transportation Power** – Appeal to market, environmental factors, high gasoline prices, 8-state MOU signatory, and adoption of stringent vehicle emissions standards.
- **Economic Development Factors** – Supportive state policies/State Energy Plan.
- **Energy Storage** – Opportunities to leverage offshore wind resources.

Weaknesses
- **Stationary Power** – Fuel cells only considered “renewable” if powered by a renewable fuel.
- **Transportation Power** – No existing hydrogen refueling infrastructure.
- **Economic Development Factors** – No fuel cell technology/industrial base at the OEM level.

Opportunities
- **Stationary Power** – More opportunity as an “early adopter market.”
- **Transportation Power** – High density state/small land area.
- **Economic Development Factors** – Some supply chain buildup opportunities/job creation.

Threats
- **Stationary Power** – Other renewable energy technologies.
- **Transportation Power** – Lack of consumer education/Lower fuel prices.
- **Economic Development Factors** – Competition from other states/regions.
### APPENDIX IV – State Energy Policy/Incentives for Stationary Fuel Cell and Hydrogen Transportation

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<tr>
<th>State Energy Policy/Incentives for Stationary Fuel Cells</th>
<th>ME</th>
<th>NH</th>
<th>VT</th>
<th>MA</th>
<th>RI</th>
<th>CT</th>
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<table>
<thead>
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<th>NH</th>
<th>VT</th>
<th>MA</th>
<th>RI</th>
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<th>NY</th>
<th>NJ</th>
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- **Eligible**
- **Eligible if Renewable**
- **Combined Heat & Power**

[www.neesc.org](http://www.neesc.org)
APPENDIX V – Summary of Potential Hydrogen and Fuel Cell Applications

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<th>Category</th>
<th>Total Sites</th>
<th>Potential Sites</th>
<th>Potential Sites</th>
<th>FCs &lt; 200 kW (#)</th>
<th>FCs &gt; 200 kW (#)</th>
<th>FCs &gt;1,000 kW (#)</th>
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<table>
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<th>Potential Targets</th>
<th>CO2 Emissions (Metric Tons/Year)</th>
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<td>FCEVs</td>
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<td>Retail Refueling Stations</td>
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The analysis provided in this Plan conservatively estimates that the near term market opportunities for the application of fuel cells (2.5 kW to 1.4 MW) totals approximately 52 MW at approximately 379 potential locations. These near term market opportunities represent a subset of the “Total Sites” that could be served by commercially available fuel cell technology. FCEV/FCEB replacements for existing fleet vehicles in Rhode Island could include the near term deployment of 185 vehicles.

---

40 Potential sites and capacity estimated by NEESC.
41 Buildings used for academic or technical classroom instruction, such as elementary, middle, or high schools, and classroom buildings on college or university campuses.
42 Buildings used for wholesale of food or for preparation and sale of food and beverages for consumption.
43 Buildings used as diagnostic and treatment facilities for inpatient care and buildings used to offer multiple accommodations for short-term or long-term residents.
44 Buildings used for the sale and display of goods other than food.
45 Buildings used for the preservation of law and order or public safety.
46 Buildings that are industrial or agricultural.
47 Buildings actively in use and managed by the General Services Administration.
48 Off-site telecommunication towers that may require back-up power.
49 Wastewater treatment plants and landfills.
50 Commercial airports, military bases, and active ports.
51 Assumes a 97% availability factor for fuel cell units ranging from 2.5 kW through 1.4 MW.
52 Many of the targets were identified based on assumptions provided by EIA’s 2012 Commercial Building Energy Consumption Survey (CBECS).