

State of the States: Fuel Cells in America 2016

7th Edition

Fuel Cell Technologies Office

November 2016



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About this Report

The information contained in this report was collected from public records, websites and via direct contact with state and industry representatives as of July 31, 2016. This report is a follow-up to State of the States: Fuel Cells in America [2015](#), [2014](#), [2013](#), [2012](#), [2011](#) and [2010](#) editions. If we have missed something in your state, please let us know at jgangi@fchea.org.

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Authors and Acknowledgements

This report was written and compiled by Sandra Curtin and Jennifer Gangi of the Fuel Cell and Hydrogen Energy Association (FCHEA) in Washington, D.C. for DOE. Support was provided by DOE's Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office.

About FCHEA

The [Fuel Cell and Hydrogen Energy Association \(FCHEA\)](#) is the trade association dedicated to the commercialization of fuel cells and hydrogen energy technologies. FCHEA represents the full global supply chain, including automakers, fuel cell materials, components and systems manufacturers, hydrogen producers and fuel distributors, government laboratories and agencies, trade associations, utilities, and other end users.

Front Cover Photo Credits

Top: Fuel cell-powered bus operated by the Stark Area Regional Transit Authority (SARTA) (Ohio). Image courtesy of SARTA.

Second: 400-kW fuel cell at CTTransit (Connecticut) which provides power to the transit agency's maintenance and storage facility. Image courtesy of [Doosan Fuel Cell America](#).

Third: 2.8-MW fuel cell system powering a wastewater treatment plant in Ontario, California. Image courtesy of [FuelCell Energy](#).

Bottom: Fuel cell-powered ground support equipment, operated by FedEx at its Memphis International Airport (Tennessee) transport hub. Image courtesy of [Plug Power](#).

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Acronyms

ARPA-E	DOE’s Advanced Research Projects Agency - Energy
CARB	California Air Resources Board
CEC	California Energy Commission
CCAT	Connecticut Center for Advanced Technology
CHP	Combined Heat and Power
DEEP	Connecticut’s Department of Energy & Environmental Protection
DOE	U.S. Department of Energy
EERE	DOE’s Office of Energy Efficiency and Renewable Energy
FCB	Fuel Cell Bus
FCV	Fuel Cell Vehicle
FCTO	DOE EERE’s Fuel Cell Technologies Office
FTA	Federal Transit Administration
kW	Kilowatt
MHE	Material Handling Equipment
MoU	Memorandum of Understanding
MW	Megawatt
NREL	DOE’s National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
PEMFC	Polymer Electrolyte Membrane Fuel Cell
RPS	Renewable Portfolio Standard
R&D	Research & Development
SBIR/STTR	U.S. Government’s Small Business Innovation Research and Small Business Technology Transfer Program
SOFC	Solid Oxide Fuel Cell
ZEV	Zero-Emission Vehicle

About Fuel Cells

A **FUEL CELL** is an electrochemical device that uses hydrogen and oxygen from the air to produce electricity, with water and heat as its by-products.

HYDROGEN can be sourced from fossil fuels, such as natural gas or propane, or renewable fuels including anaerobic digester gas and landfill gas. Hydrogen can also be produced by water electrolysis, which can be powered by electricity from renewables such as solar or wind power or from nuclear energy and the grid.

FUEL CELL BENEFITS

- Exceptionally low/zero emissions
- High quality, reliable power
- Durable and rugged
- Efficient – 50%+ electric efficiency, 90%+ electric and thermal efficiency (combined heat and power)
- Quiet
- Fuel flexible – can use conventional or renewable fuels

FUEL CELL CAPABILITIES

Motive

- Fuel Cell Vehicles (FCVs) – replicates today's driving experience: range of ~300 miles per hydrogen fueling, refuel at a pump in 3-5 minutes
- Material Handling Equipment (MHE) – fuel cell provides constant power, without lag, over an entire shift, reliable operation in refrigerated environments, can refuel in minutes

Stationary

- Flexible siting – indoors or outdoors
- Lightweight – enables rooftop siting
- Modular/scalable to meet any need, ranging from a few watts to multi-megawatt systems
- Able to provide primary, supplemental, or backup power
- Can be grid-tied, or can operate independently from the grid
- Compatible with solar, wind, batteries and other renewable/conventional technologies
- Can be used with, or instead of, fossil fuel generators
- Requires less space than solar photovoltaics
- Operates in water balance/uses very little water in operation

Portable

- Refuel on the go by swapping a cartridge
- Provides longer run times
- Low-thermal, low-sound profile

EXAMPLES OF FUEL CELL APPLICATIONS

At the state and local level, fuel cells are helping meet environmental goals, boosting reliability and resiliency to ensure constant power, and saving taxpayer dollars and industry investment.

This includes primary and backup power to:

- Government offices, jails, fire and police stations
- Wastewater treatment plants
- Communications and emergency networks
- Schools and hospitals
- Zoos, parks and gardens

Motive power for:

- Airports (baggage tow tractors, nose wheels)
- Ports (MHE)
- Fleet vehicles

In the private sector, applications include some of the above as well as:

- Facilities, such as retail stores, corporate headquarters, data centers, hotels, apartment buildings
- Cell phone towers
- Railroad signals
- Electric grid substations, providing multi-megawatts of power to local users
- Off-grid equipment for security, energy exploration, recreation
- MHE
- Buses operating on public routes
- Automobiles

Introduction: Fuel Cells Deployments on the Rise

The fuel cell footprint is growing in the U.S. on a variety of levels. The industry consists of companies large and small, located in states across the country, representing the entire spectrum from components to systems to integrators and end users. Installations and deployments are increasing every year, in number and in megawatts (MW). Cities are adopting fuel cells to power essential services when the grid goes down. Railroad and telecom companies use fuel cells to power communication towers and signaling infrastructure. Major corporations are not only installing hundreds of fuel cell systems to power retail sites, data centers, and other facilities, they are also deploying fuel cell-powered forklifts in warehouses and distribution centers across the country. Fuel cell vehicles (FCVs) are available for purchase or lease in California and fuel cell buses are in operation in several states.

While these deployments have been encouraged by federal research and development (R&D) and demonstration programs, and supported by federal tax incentives for FCVs, hydrogen infrastructure, and fuel cell stationary power generation, it is the support and investment by state governments that have propelled the use of fuel cell and hydrogen technologies in certain parts of the country.

Top 3 Fuel Cell States

The top states for fuel cells promote the technology through programs and coalitions, planning and roadmaps, funding and incentives, business support and R&D, and do so to encourage zero-emission transport and clean, efficient distributed power generation. Some states also target fuel cells and hydrogen as a growth industry for new jobs and as a revenue driver for the state.

The Top 3 states also have invested in the technology for the long-term, often with bipartisan support – extending through consecutive gubernatorial administrations and legislative terms – and have developed ongoing fuel cell and hydrogen programs and incentives (and often have included them as eligible technologies within other programs). This commitment has encouraged municipalities, schools, and commercial businesses – from Fortune 500 corporations to small family-owned businesses – to adopt fuel cell technologies in these states.

CALIFORNIA

By The Numbers:

Hyundai Motor America (Fountain Valley) and Toyota USA (Torrance) sell or lease fuel cell vehicles (FCVs) in California, with **more than 350 FCVs in California** as of August 2016, and Honda Motor Company (Torrance) will bring its FCV to market in California late 2016.

California has **nearly 50 hydrogen fueling stations open or in development.**

FUEL CELLS BY THE NUMBERS – NATIONALLY

- There are **more than 235 MW** of large stationary (100 kW to multi-megawatt) fuel cells currently operating in the U.S. Fuel cell power plants are **located in at least 43 states**, providing power to commercial and municipal operations. **CALIFORNIA** is home to the greatest number of stationary fuel cells, while **CONNECTICUT** and **DELAWARE** are home to the largest installations (14.9 MW and 30 MW, respectively).
- **More than 11,000 fuel cell-powered forklifts** operate in commercial warehouses and distribution centers **in at least 26 states**.
- **Fuel cells provide backup power** to off-grid equipment owned by telecoms and railroads, with hundreds operating in **more than 40 states**.
- **Fuel cell passenger vehicles** are now sold and leased in **CALIFORNIA**, with **more than 350** currently on the road. The state is also home to **20 public retail hydrogen fueling stations**.

U.S. FUEL CELL POLICIES

- **30 states** include fuel cells or hydrogen as eligible resources in Renewable Portfolio Standards.
- **32 states** permit net metering of fuel cells.
- **25 states** offer funding for fuel cells in the form of rebates, grants, loans, bonds, PACE financing, or public benefits funding.
- **16 states** provide personal, corporate, property and/or sales tax incentives for fuel cells.

18 fuel cell buses are operating in transit service.

California has more fuel cell distributed power generation than any other state, with more than **480 fuel cell systems, totaling more than 210 MW** of power generation, that were placed in service with the support of state grants.

Major Influencers – State Agencies and Organizations:

California's state government and agencies, such as the Office of Business and Economic Development (GO-Biz), the California Air Resources Board (CARB), California Energy Commission (CEC), the state's Air Quality Management Districts (AQMDs), the California Fuel Cell Partnership (CaFCP), Alameda-Contra Costa Transit District (AC Transit), SunLine Transit, and other transit agencies operating fuel cell buses.

Key Programs and Policies:

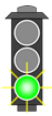
CARB's [Advanced Clean Cars Program](#) builds upon the state's [Zero Emission Vehicle \(ZEV\) Regulation](#), and the [Clean Vehicle Rebate Project](#) (CVRP) provides a \$5,000 rebate for FCVs.¹

Assembly Bill 8, enacted in 2013, includes a provision to fund at least 100 hydrogen stations with a commitment of up to \$20 million per year and the Energy Commission's [Alternative and Renewable Fuel and Vehicle Technology Program](#) (ARFVTP) supplies funding for these hydrogen stations.

The [Fleet Rule for Transit Agencies](#) that established a demonstration and purchase requirement of ZEVs, including FCVs, for large transit agencies.

The [Self Generation Incentive Program](#) (SGIP), which provides grant funding to support the deployment of distributed power generation resources, including stationary fuel cells.

Assessment:



California continues to display unparalleled leadership in the area of FCV incentives and hydrogen infrastructure. The state's ongoing planning and support led it to be one of the first places in the world (and the first in the U.S.) to have commercial zero-emission FCVs on its roadways.



California is #1 in stationary fuel cell power. But recent [modifications](#) to SGIP incentives¹ will reduce the program's allocation to generation technologies – including fuel cells, wind, waste heat to power, and combined heat and power technologies – to just 25% of the program's overall budget.

"Hydrogen fuel cell electric and plug-in electric vehicles are pathways to achieve healthier and cleaner air for our communities. San Francisco is committed to reducing the number of vehicles on the road by investing in sustainable transit options and ensuring that vehicles on the road will be zero emissions."

– San Francisco [Mayor Edwin Lee](#)

CONNECTICUT

By The Numbers:

Conservatively, at least **35 MW of fuel cells** now operate in the state and another **20 MW are planned**. A **63.3-MW fuel cell installation** has been approved by Connecticut's Siting Council. This would be the world's largest fuel cell power park, surpassing a 59-MW fuel cell installation in Korea.

In 2017, a public hydrogen fueling station will be opened in Hartford, **one of 12 initial northeast U.S. hydrogen stations** under development by Toyota and Air Liquide.

CTTransit, a bus system that is a division of that state's Department of Transportation, began operating demonstration fuel cell buses in 2007 and now operates **one fuel cell bus** in daily revenue service.

Fuel cells and hydrogen are a key industry sector in Connecticut. Several major fuel cell manufacturers are located in the state and **more than 600 companies are part of the fuel cell and hydrogen supply chain**. In 2015, the industry realized **\$726 million in revenue and investment**, generated **3,400 direct, indirect and induced jobs** and more than **\$340 million in labor income**, and contributed more than **\$39 million in state and local tax revenues**.²

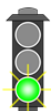
Major Influencers – State Agencies and Organizations:

Connecticut's state government and agencies, such as the Department of Energy and Environmental Protection (DEEP), Department of Economic and Community Development (DECD), the state's U.S. senators and representatives, the Connecticut Hydrogen-Fuel Cell Coalition (CHFCC), CTTRANSIT, and the Connecticut Center for Advanced Technology (CCAT).

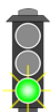
Key Programs and Policies:

DEEP's [Fuel Cell Program](#) provides incentive funding through the [Connecticut Green Bank's](#) On-Site Distributed Generation Program, the [Microgrid Grant and Loan Program](#), and the [Low and Zero Emissions Renewable Energy Credit Program](#) (LREC/ZREC).

Assessment:



Connecticut's support for stationary fuel cells is strong, deploying the technology to enhance power reliability and reduce emissions. The state has provided funding for microgrids to provide reliable power during adverse weather events, and many include fuel cells. A number of cities or towns are also siting fuel cells on brownfield sites, putting marginal land to good use. Policies and activities such as these have made the state #2 in stationary cell installations, with 35 MW installed and more than double that amount proposed or in development.



Connecticut is preparing for FCVs, and the [Connecticut Hydrogen and Electric Automobile Purchase Rebate](#) (CHEAPR) offers \$5,000 to purchasers or lessors of the Hyundai Tucson Fuel Cell and Toyota Mirai. This is timely, since the state's first public hydrogen station is set to open in late 2016.

"This project, when completed, will bring extraordinary benefits to the community and region through its clean energy generation, economic development of a former industrial site and manufacture and use of Connecticut-based fuel cell technology."

– [Excerpt](#) from a joint letter sent to the Connecticut Siting Council by members of Connecticut's Congressional Delegation including Senators Blumenthal and Murphy and Representatives Larson, DeLauro, and Esty, in support of the proposed 63.3-MW Beacon Falls fuel cell energy park

NEW YORK

By The Numbers:

New York is home to **more than 180 companies** that are part of the hydrogen and fuel cell industry.³

More than **14 MW of fuel cells** operate in New York, some going back a decade or more.

In 2017, a public hydrogen fueling station will be opened in the Bronx, **one of 12 initial northeast U.S. hydrogen stations** under development by Toyota and Air Liquide.

Major Influencers – State Agencies and Organizations:

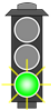
New York's state government, U.S. senators and representatives, the New York State Department of Public Service and Commission, New York State Energy Development Authority (NYSERDA), and New York Power Authority (NYPA).

Key Programs and Policies:

New York's [Reforming the Energy Vision](#) (REV) strategy, New York's Clean Energy Standard, sales and use tax exemption, [NY Prize](#) microgrid program, and NYSEDA's fuel cell R&D program for New York companies.

"Fuel cell technology has come a long way and will be an important resource as we carefully move forward in modernizing New York's electricity grid."

– State Senator [Joseph Griffo](#) (R-Rome) speaking of NYSEDA's 10th solicitation (2015) under New York's renewable portfolio standard (RPS), in which fuel cells, for the first time, could receive up to 20-year contracts

Assessment:

New York includes all fuel cell systems in their Renewable Portfolio Standard and in the new Clean Energy Standard (released in 2016) and provides a sale and use tax exemption for fuel cell systems and service, and hydrogen gas. The state also has a microgrid program designed to ensure reliable power generation, even during adverse weather events. These programs are helping to fund growing numbers of fuel cells in the state.



NYSERDA has historically supported fuel cells through a dynamic and successful program, but has recently diminished the scale of the program, shifting funding to combustion-based combined heat and power (CHP).^{4, 5}

“The Rochester area is an emerging leader in fuel cell and renewable energy development, with RIT’s Golisano Institute for Sustainability leading the way. This is a good first step as we continue our work to offer a stronger package of incentives to spur fuel cell development in our community and across the state.”

– State Senator [Rich Funke](#) (R-Rochester), also speaking of NYSERDA’s 10th solicitation under the RPS

More 2016 Top Fuel Cell States

COLORADO

By The Numbers:

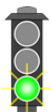
Two private hydrogen stations are located in Golden at DOE’s National Renewable Energy Laboratory (NREL). The first, opened in 2009, is a station that uses wind power to produce hydrogen. The second, opened in October 2015, is part of NREL’s new Hydrogen Infrastructure Testing and Research Facility.

Major Influencers – State Agencies and Organizations:

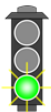
Colorado’s legislature and governor, the Colorado Division of Oil & Public Safety, Colorado Hydrogen Coalition, and NREL.

Key Programs and Policies:

Colorado’s governor signed a legislative measure in March 2016 requiring the state’s Division of Oil and Public Safety to promulgate rules by 2017 concerning retail hydrogen fuel for vehicles. The bill also amends the state’s definition of “fuel products” to include hydrogen.

Assessment:

Colorado has strong expertise in fuel cell and hydrogen R&D. NREL performs RD&D and analysis on hydrogen production and delivery, hydrogen storage, and fuel cell technologies for transportation, stationary and portable applications, as well as the development of hydrogen codes and standards for buildings, components, systems, and vehicles.



The Colorado Hydrogen Coalition, an initiative of the [Colorado Cleantech Industries Association](#), was formed in 2014 to accelerate development of the hydrogen fuel cell technologies market in Colorado.

“The DOE National Renewable Energy Laboratory and its fuel cell R&D work, expert staff, hydrogen station and fuel cell vehicles test fleet are the cornerstone of fuel cell activities in Colorado. But also there are 25 or more Colorado companies identified in the fuel cell industry supply chain or using fuel cells in material handling or remote power, plus engineering and professional services and multiple university research programs underway in the fuel cells sector. Most of these are part of the nearly 100-member Colorado Hydrogen Coalition, an initiative of Colorado Cleantech Industries Association (CCIA). Colorado is also a common site for OEM’s to test fuel cell vehicles, especially for high-altitude performance and sometimes they make use of NREL’s fueling station.”

– Jack Paterson, Chair of Colorado Hydrogen Coalition, an initiative of CCIA

HAWAII

By The Numbers:

Toyota Japan and SERVCO Hawaii brought 6 production Mirai's vehicle to Hawaii in January 2016, making it the **second state after California to receive the Mirai**. Servco Hawaii is building a fueling station in Mapunapuna (Proton OnSite) and uses the Mirai to promote hydrogen vehicles and infrastructure in the state.

The Servco Hawaii station will be the state's **first public hydrogen station** with a targeted commissioning date of January 2017. Military hydrogen stations located at Marine Corps Base Hawaii and Joint Base Pearl Harbor-Hickam (JBPHH), are used to fuel FCVs operated by the military.

Hawaii is home to **more than a half dozen advanced fuel cell and hydrogen projects**. These include:

- A Hawaii Center for Advanced Transportation Technologies (HCATT)-sponsoring a demonstration of a waste-to-energy (gasifier) generating system at JBPHH, converting 10 tons of waste daily to electricity. The system is projected to be further tested for the production of hydrogen from waste for use in JBPHHs FCVs.
- The recently completed Maritime Fuel Cell Generator Project, led by DOE's Sandia National Laboratory, used a containerized 100-kW Hydrogenics hydrogen fuel cell generator to deliver refrigerated container power on land and sea. A six-month field trial was hosted by Young Brothers Ltd., a subsidiary of Foss Maritime Co., at its facility in the Honolulu Harbor.
- Blue Planet Research (private) currently demonstrates a hydrogen energy storage system supported by a 100% renewable micro-grid at Puu Wa'a on the Big island. They are also under contract with NASA to operate a Mars Habitat using hydrogen for extended energy storage in support of that micro-grid. Both projects have been operating over three years.
- Planned projects:
 - A fleet of eight shuttle fuel cell transit buses at Honolulu International Airport, to be operated by the Hawaii Department of Transportation starting in 2018.
 - A hydrogen and battery energy storage project at the Hawaii Air National Guard F-22 Campus with a long term goal of a 100% hydrogen flight line;
 - Three public fuel cell electric hybrid shuttle buses on the Big Island, one operated by the County of Hawaii Mass Transit Agency and two at Hawaii Volcanoes National Park (HAVO).
 - A joint USDOE-DOD technical validation project to demonstrate the use of electrolyzer technology to simultaneously produce hydrogen for fuel and for grid management. Hydrogen produced at the Natural Energy Laboratory Hawaii Authority (NELHA) plant will be used to fuel the Big Island's three public fuel cell shuttle buses.
 - A hydrogen fueling station located at HAVO.

Major Influencers – State Agencies and Organizations:

Hawaii's legislature and governor, the state's Hydrogen Implementation Coordinator, Hawaii Implementation Working Group, State Energy Office, High Technology Development Corporation (HTDC) (state agency), Hawaii Natural Energy Institute, and Hawaii Center for Advanced Transportation Technologies (HCATT)

"As the most oil dependent state in the nation, Hawai'i spends roughly \$5 billion a year on foreign oil to meet its energy needs. Making the transition to renewable, indigenous resources for power generation will allow us to keep more of that money at home, thereby improving our economy, environment and energy security."

– [Hawaii Governor David Ige](#)



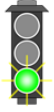
Governor David Ige has only driven twice since he became the Governor of Hawaii and both times he drove the Toyota Mirai FCV

Photo source: Servco Toyota

Key Programs and Policies:

Hydrogen Investment Capital Special Fund, Hawaii Hydrogen Initiative, 2010 to 2020 Renewable Hydrogen Plan. In 2016 the State Legislature authorized \$1.25 million in bonds to design the refueling infrastructure for the Department of Transportation airport shuttle bus project.

Assessment:



To reduce the island's dependency on fossil fuels, Hawaii has set a goal of 100% clean energy by 2045 and has "embraced bold solutions that will help develop this competitive industry, making Hawaii one of the leaders in the clean energy race."⁶ Hawaii is taking strong steps to become a leader in hydrogen and fuel cells and the technologies are set to play a strong role in the state's energy transition.

MASSACHUSETTS

By The Numbers:

Massachusetts has **at least 300 companies** that are part of the Northeast region's hydrogen and fuel cell industry supply chain.⁷

In 2017, **two public hydrogen fueling stations** will be opened (Mansfield and Braintree), part of an initial network of twelve northeast U.S. hydrogen stations under development by Toyota and Air Liquide.

As part of a Federal Transit Administration (FTA) project for Massachusetts Bay Transportation Authority (MBTA), Nuvera, of Billerica, Massachusetts, completed the installation of a hydrogen generation and fueling station that will fuel Boston's **first fuel cell-powered public city bus**.

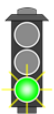
Major Influencers – State Agencies and Organizations:

The Department of Energy Resources (DOER), Zero Emission Vehicle Commission, and the Massachusetts Hydrogen Coalition.

Key Programs and Policies:

The [MOR-EV](#) program, funded by DOER, issues rebates to electric vehicle drivers, including \$2,500 rebates to drivers of the Hyundai Tucson Fuel Cell and the Toyota Mirai.

Assessment:



Like Connecticut, Massachusetts is preparing for FCVs and the state's first two hydrogen stations by offering FCV rebate incentives to customers.

"To have Littleton be the host community for one of the first hydrogen filling stations in the northeast for this joint venture to introduce hydrogen fuel cell electric vehicles to the United States would be a unique opportunity to advance our sustainability principles as a Green Community."

– [Littleton, Massachusetts, Town Administrator Keith Bergman](#), commenting on the Planning Board's unanimous decision (April 2016) to accept an Air Liquide hydrogen distribution facility site plan. The facility will supply hydrogen that will be delivered by tube trailers to hydrogen fueling stations in the region.

NEW JERSEY

By The Numbers:

The New Jersey Clean Energy Program (NJCEP) reports that, for the period 2012-2014, **12 fuel cell systems** were installed, or had funding committed, totaling **more than 12.5 MW**.⁸

Key Programs and Policies:

NJCEP's [CHP Program](#), under which certain fuel cells qualify.

Assessment:



In 2016, NJCEP revised fuel cell eligibility under the CHP Program (formerly called the Fuel Cell-CHP program). Fuel cells without heat recovery have been suspended from participation in the program. Fuel cell systems with heat recovery, sized greater than 3 MW, are eligible for incentives under the current CHP Program.

"If we're going to reinvigorate New Jersey's economy, we need to make sure New Jersey is at the cutting-edge of innovation. Doing so will ensure high-paying jobs and exciting economic growth for years to come, and hydrogen fuel cell technology must be a part of that effort. We need to foster jobs and economic development, but if we can do so while also reducing dependence on foreign oil, cutting pollution and boosting clean energy, then everybody wins."

– New Jersey Assemblyman [Gordon Johnson](#) (D-Bergen)

OHIO

By The Numbers:

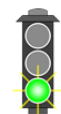
Ohio is home to a major fuel cell industry that includes fuel cell component and material suppliers, stack and systems integrators, and balance of plant equipment and service providers. The state's industry group reports that there is not a fuel cell manufactured in the U.S. that does not have Ohio components. In 2015, **more than \$100 million** in fuel cell components were purchased from Ohio companies and an additional **\$150 million** was invested in 2015 by Ohio industry for fuel cell development.

By 2018, the Stark Area Regional Transit Authority (SARTA) (Canton) will have the **second largest fuel cell bus fleet** in the nation. The 10 buses, funded under FTA's National Fuel Cell Bus Program (2 buses) and No and Low Emission program (8 buses), will join SARTA's fleet in 2017 and 2018.

Major Influencers – State Agencies and Organizations:

The Ohio Fuel Cell Coalition (OFCC) and SARTA. Business support is provided by JobsOhio, Team Neo, Ohio Development Services Agency, Columbus 2020, and the Dayton Development Coalition.

Assessment:



Ohio's growing fuel cell industry cluster is supported by the OFCC and local business development organizations, and a strong R&D capacity at local businesses, colleges, and universities.

"Along with enabling us to cut our fuel costs by as much as fifty percent in the years ahead and maintain our position as trailblazers in the use of green technology to fuel public transit, this project will drive investment, research, business development and job creation in Stark County and across our state. Honda, Worthington Industries, LG Fuel Cell Systems, Swagelok and other Ohio companies as well as universities including Ohio State, Stark State and Cleveland State University, are heavily involved and invested in fuel cell and hydrogen-related manufacturing and R&D projects."

– SARTA Executive Director/ CEO [Kirt Conrad](#), speaking of the agency's fuel cell buses that will be delivered in 2017 and 2018

U.S. Jobs and the Economy

As the fuel cell industry grows around the world, partnerships, memorandums of understanding (MoU), and other business arrangements are opening up opportunities for sales and distribution for U.S.-based companies on every level, from fuel cell manufacturing, to hydrogen generation and delivery, to the supply chain and integration. Companies are expanding international efforts and increasing exports to other countries, and as new companies enter the fold, the fuel cell and hydrogen industry is helping drive manufacturing growth and create jobs across the country.

In March 2016, the Northeast Electrochemical Energy Storage Cluster (NEESC), administered by CCAT, released the details of an [economic analysis](#) of the Northeast region's fuel cell and hydrogen industry (**CONNECTICUT, MAINE, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, RHODE ISLAND, VERMONT**). The analysis found that the industry experienced growth over the last four years in employment, revenue and investment, labor income, and state and local tax revenue.

In 2015, the **NORTHEAST** U.S. hydrogen and fuel cell supply chain contributed:

- Nearly \$1.4 billion in revenue and investment.
- More than 6,550 direct, indirect and induced jobs.
- Labor income of approximately \$620 million.

2015 state and local tax revenues stemming from the Northeast region's hydrogen and fuel cell industry were in excess of \$83 million.

CCAT also reports that several key companies in the Northeast region experienced growth in either employment or investment and revenue, including Doosan Fuel Cell America (**CONNECTICUT**), FuelCell Energy (**CONNECTICUT**), Proton OnSite (**CONNECTICUT**), and Plug Power (**NEW YORK**).

"We were very pleased to see growth in the [hydrogen and fuel cell] industry here in the Northeast given the competitive nature of the industry and the significant recruitment efforts from other countries. The policies and programs in place to support these companies from the individual states and several federal agencies, such as the Small Business Administration and the Department of Energy has really paid off."

– [CCAT's Director of Energy Initiative Joel Rinebold](#)

An April 2016 report, [Advanced Energy Jobs in California](#), authored by Advanced Energy Economy Institute (AEEI), shows that **CALIFORNIA**'s advanced energy economy is growing six times faster than the overall economy and represents 3% (500,000) of workers across the state. The state's Advanced Transportation segment showed growth of 65% in 2015, the second highest of any segment. Three percent of this Advanced Transportation workforce focuses on FCV technologies, equating to about 600 workers. With automakers introducing FCVs into the California market, this number is poised to grow.

The report also finds that about one percent of the California's advanced electricity generation employment involves fuel cells, equal to about 1,400 workers.

The authors find the potential for sustained growth of advanced energy in the state and claim that, "as the market matures, California will see greater specialization in energy efficiency, business expansion, revenue growth, and changes in the state's overall composition of advanced technologies. These factors will continue to allow California's advanced energy industry to grow and thrive, and employment along with it."

AEEI also released a similar report in July 2016 focused on Florida, which found that 38% of the almost 8,000 advanced transportation jobs in the state were related to fuel cell vehicles.⁹

An example of a company that has grown since entering this industry is PDC Machines, which has found success in the hydrogen market for its compressor products. The company has partnered with major gas producers, technology and research companies, and now has more than 230 compressors currently in use at demonstration and commercial installations, throughout the world, for hydrogen refueling of vehicles, buses, material handling vehicles and experimental aircraft. In 2010, the alternative energy business comprised 20% of PDC's activities, growing to 58% in 2015. In that same period, bookings increased by 144% and the company boosted personnel by 22%.

Manufacturing Expansion

Meeting the demand in certain markets in the U.S. and around the world is helping contribute to a resurgence of manufacturing. Since our last report, several companies have reported on plans to expand operations, creating jobs and strengthening the local economy.

FuelCell Energy held a groundbreaking ceremony in November 2015 for its Torrington, **CONNECTICUT**, manufacturing facility expansion that will grow production capacity from 100 MW to at least 200 MW to accommodate orders. The state is providing a financial package that includes \$20 million of low interest long-term loans and up to \$10 million of tax credits, predicated on certain terms and conditions, including the forgiveness of up to 50% of the loan principal if job retention and job creation targets are reached. The company plans to add up to 325 jobs as it doubles its manufacturing capacity.

NEW YORK fuel cell manufacturer Plug Power announced it was adding a second shift (12 employees) at its Latham factory to double output.¹⁰ Plug Power now employs more than 300 people, an increase from about 80 employees five years ago.

GE Fuel Cells is expanding at the Saratoga Technology + Energy Park in Malta, **NEW YORK**, with plans to build a new test site for its 1-MW fuel cells.¹¹ NYSERDA, which owns and manages the research park, approved the request for a new lease, which includes 9,986 square feet of land and improvements. The business already has 20,000 square feet of manufacturing, research and office space at the tech park.

HEC-TINA – created by the January 2015 merger of the Hydrogen Energy Center (U.S. manufacturer of hydrogen combustion engines) and TINA Technologies (Spanish electrolyzer manufacturer) – opened its new Greeneville, **TENNESSEE**, plant in October 2015.¹² HEC-TINA's product generates renewable hydrogen using wind and solar electrolysis, which can be stored and used to provide up to 100 kilowatts (kW) of power when needed.

German portable fuel cell manufacturer eZelleron opened a new office in Palo Alto, **CALIFORNIA**, in April 2016.¹³ eZelleron was selected by German Accelerator as a winning startup and will spend up to a year in the U.S. German Accelerator supports high-potential German startups and emerging companies to successfully enter the U.S. market and scale their business internationally.

Partnerships and Agreements

FuelCell Energy and ExxonMobil (Irving, **TEXAS**) announced an agreement to pursue power plant carbon dioxide capture through a new application of carbonate fuel cells.¹⁴ The companies report that laboratory tests have demonstrated that integration of carbonate fuel cells and natural gas-fired power generation captures carbon dioxide more efficiently and has the potential to substantially reduce costs associated with carbon capture.

"The \$10 million loan to FuelCell Energy, Inc. represents a smart investment in a leading global fuel cell company with its manufacturing facility here in Torrington. It's critical that we support the growth of this important industry that will boost the economy and create more jobs in our region of the state."

– [Connecticut State Representative Roberta Willis](#)

Growing Companies Commended by White House

Two fuel cell and hydrogen companies were singled out for their commitment to hiring veterans in support of First Lady Michelle Obama and Dr. Jill Biden's Joining Forces Initiative. Air Liquide (U.S. headquarters in **TEXAS**) has pledged to make veterans 10% of their annual hires and PDC Machines (**PENNSYLVANIA**) committed to have veterans or military spouses comprise 8%-10% of their workforce by 2020.



First Lady Michelle Obama with PDC Machines founder Syed Afzal (r) and Vice President Kareem Afzal (l)

3M (St. Paul, **MINNESOTA**) entered into an agreement with Plug Power (Latham, **NEW YORK**) to supply membrane electrode assemblies (MEAs) for Plug Power-designed proton exchange membrane (PEM) fuel cell stacks.¹⁵

Environmental and Technical Controls Inc. (Southfield, **MICHIGAN**) signed a MoU with GEI Global Energy Corp. (Flint, **MICHIGAN**) to manufacture, market, and sell GEI's fuel cell power systems.¹⁶ The two companies plan to build a \$24 million, 50,000-sq-ft manufacturing plant on a 14-acre brownfield site to manufacture fuel cells and components. The start of operations is anticipated by February 2018.

Solar Stik™, Inc. (St. Augustine, **FLORIDA**) and fuel cell manufacturer SFC Energy (Germany) entered the first phase of a cooperative venture that will allow SFC Energy to service its fuel cell products at Solar Stik's St. Augustine facility. SFC Energy's U.S. headquarters will be located in Winter Park, **FLORIDA**.¹⁷

In March 2016, investor Mitsui & Co. (Japan) acquired a 25% stake in Hexagon Composites (Norway), spending an estimated ¥11 billion (\$105 million) to focus on the FCV supply chain.¹⁸ In April, Mitsui, Toray Industries (Japan), and Hexagon's subsidiary, Hexagon Lincoln (Lincoln, **NEBRASKA**), entered into a joint development agreement to conduct a business viability study of a proposed joint venture to manufacture and sell carbon fiber reinforced high-pressure hydrogen cylinders for vehicles in Japan.¹⁹ In August 2016, Hexagon Lincoln was also selected by Daimler AG to supply compressed hydrogen gas cylinders for Daimler's next generation FCV, the Mercedes-Benz GLC F-CELL, which will be presented in 2017.²⁰

Earlier, with financial support from DOE's Office of Energy Efficiency and Renewable Energy, Hexagon Lincoln developed carbon fiber composite fuel tanks for use in transporting hydrogen across the country.²¹ The trailers use high-strength composite vessels that haul more than 720 kilograms of hydrogen, more than double the amount of traditional steel tube trailers. The increased business helped Hexagon to increase the number of its employees from 119 to 269.

International Activities

Doosan Fuel Cell America (South Windsor, **CONNECTICUT**) manufactured 70 fuel cell systems totaling 30.8 MW in Connecticut and shipped the fuel cells to Korea to partners Samsung C&T Corp. and Korea Hydro & Nuclear Power (KHNP) to install as part of a clean energy project.²² Doosan was also selected as the preferred bidder on a 39.6-MW fuel cell power plant project in Incheon's Songdo business district. The total cost is 220 billion won (\$193 million). The plant will supply 300,000 megawatt-hours (MWh) of electricity annually.

Doosan also finalized a partnership with Korea Western Power and Serveone, an LG affiliated company, to manufacture 11 fuel cells (totaling 5 MW) in Connecticut to export to Korea. Once installed, the PureCell® Model 400 power plants will generate power for nearly 3,000 homes in Incheon.²³

FuelCell Energy (Danbury, **CONNECTICUT**) continues to ship two 1.4-MW fuel cell kits per month to POSCO Energy, under a long-term purchase and sale contract the two companies signed in 2012. The shipments, which totaled 33.6 MW (24 kits) in 2015, are scheduled to continue into late 2016.

FuelCell Energy also announced a contract with Cenovus Energy Inc., a Canadian integrated oil company, to complete the preliminary front-end design and engineering for siting a fuel cell system to capture carbon dioxide (CO₂) from flue gas.²⁴ The system would be at an existing 14-MW, natural gas-fired co-generation facility located at the University of Calgary in Alberta, Canada.

Plug Power (Latham, **NEW YORK**) sold 200 GenDrive fuel cells to European supermarket company Colruyt Group to put into forklifts at its Halle, Belgium, facility.²⁵ Plug Power also received a purchase order from FM Logistic for Plug Power's GenDrive products to power pallet jacks and reach trucks in its logistics facility in Neuville-aux-Bois, France.²⁶

Export Recognition

In May 2016, Vairex Air Systems (Boulder, **COLORADO**) received the [President's "E" Award](#) for exports, the highest recognition any U.S. entity can receive for making a significant contribution to the expansion of U.S. exports. Vairex has a sales office in Tokyo, Japan, and ships its compressor system to 17 countries in North America, Asia and Europe for a range of fuel cell applications.

Last year, Proton OnSite (Wallingford, **CONNECTICUT**) received the "E" award for its PEM electrolysis system.

Air Products (Allentown, [PENNSYLVANIA](#)) and Nippon Steel & Sumikin Pipeline & Engineering Co. Ltd. are working together to construct hydrogen fueling stations in Japan, completing its first retail station in Tokyo²⁷ with a second station under construction in Hokkaido.

Dominovas Energy Corporation (Atlanta, [GEORGIA](#)) launched its first RUBICON™ SOFC system in Johannesburg, South Africa. Launched in partnership with the South Africa-based Edison Power Group (EPG), the 50 kW RUBICON™ system will serve as a demonstration unit for future Edison Power Group sponsored multi-megawatt, utility scale deployments in Africa.²⁸

Neah Power Systems (Bothell, [WASHINGTON](#)) signed a MoU with a South African company to license its PowerChip® fuel cell technology, Formira HOD® (hydrogen on demand) technology, and BuzzBar charger technology for portable electronics.²⁹

Federal Support for U.S. Technologies

The U.S. Department of Energy (DOE) awards funds through various programs and projects to companies, universities, National Laboratories and other organizations across the U.S. to support research and development, early market deployments, and domestic manufacturing of hydrogen and fuel cell technologies, helping to advance America's innovation in hydrogen and fuel cell technologies.

DOE issues formal requests for proposals and solicitations on specific topics as well as through the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) program. Since our last report, DOE has selected projects for more than \$40 million in funding to support Energy Efficiency and Renewable Energy (EERE) /Fuel Cell Technologies Office (FCTO) and Office of Science (SC)/Basic Energy Sciences (BES) RD&D projects around the country focused on a range of areas, including catalysts, solid oxide fuel cells (SOFCs), PEM fuel cells, regenerative fuel cells, hydrogen production, and hydrogen infrastructure development.

- The DOE/Small Business Vouchers Pilot program awarded about \$1 million in funding for companies to partner with DOE national laboratories to help move innovative technologies closer to the marketplace. Seven fuel cell and hydrogen companies were included in the first round.³⁰
- DOE selected the city of San Francisco as its first Climate Action Champion to pursue hydrogen and fuel cell technologies for local transportation, and was awarded a share of \$4.75 million for the development of education and outreach programs to increase the deployment of FCVs and hydrogen infrastructure.³¹ Strategic Analysis, Inc. was also selected to provide detailed cost analyses for hydrogen fuel cell systems, hydrogen storage, and hydrogen production and delivery technologies.
- DOE's Advanced Research Projects Agency - Energy (ARPA-E) awarded more than \$5 million to two fuel cell companies through its OPEN 2015 Awards.
- Through two collaborative research consortia, the [Fuel Cell Consortium for Performance and Durability](#) (FC-PAD) and [Hydrogen Materials—Advanced Research Consortium](#) (HyMARC), DOE awarded more than \$13 million in funding for advanced hydrogen storage and fuel cell performance and durability projects.³²

“Connecticut companies have always led the way in developing new technologies that improve energy efficiency and protect our environment. For 18 years, Proton OnSite has raised the bar by exporting clean energy solutions across the globe, and I’m thrilled that DOE is recognizing their extraordinary contributions.”

– [U.S. Senator Chris Murphy](#) (CT) speaking about the \$2.5 million DOE ARPA-E OPEN award to Proton OnSite

“This investment will support private research and development projects that will spur innovation to help modernize our electric grid and provide clean-energy solutions to combat climate disruption. New Mexico’s history of ingenuity and creating new technology drives our economy and contributes to our great nation. By developing new ways to generate, deliver, store and use energy, we not only create jobs, but we also inspire the next generation of STEM leaders and entrepreneurs.”

– [U.S. Sen. Martin Heinrich](#) (NM) speaking about the 2015 DOE ARPA-E OPEN award to Pajarito Powder

- In January 2016, SimpleFuel, a collaboration of three companies, Ivys Energy Solutions (Waltham, **MASSACHUSETTS**), McPhy Energy N.A. (Newtown, **MASSACHUSETTS**), and PDC Machines (Warminster, **PENNSYLVANIA**), was selected as the finalist of the H2 Refuel H-Prize Competition, launched by DOE's FCTO and the Hydrogen Education Foundation.³³ SimpleFuel must complete construction of its small scale, on-site hydrogen generation and fueling system by summer 2016. Afterward, testing and collection of technical and cost information will begin, to be analyzed in the fall after competition closes. If the system meets criteria, SimpleFuel could win the \$1 million prize, which will be announced in early 2017.
- The Technology Commercialization Fund (TCF) works to expand the commercial impact of DOE's portfolio of research, development, demonstration and deployment activities by partnering National Laboratories with industry. Round 1 funding awards include \$1 million in funding for fuel cell and hydrogen projects.³⁴

'Big Ideas' are identified by National Laboratory teams as high impact areas that are currently underemphasized or potentially valuable additions to the DOE portfolio. A concept that emerged from the Big Idea Summit is H2@Scale³⁵, which seeks to decrease the use of carbon in the U.S. electricity generation, transportation, and industrial sectors by increasing renewable hydrogen generation and wide-scale deployment of hydrogen for energy storage.

Fuel cell and hydrogen research is also funded by other federal agencies. In 2016, the Department of Defense (DOD), National Aeronautics and Space Administration (NASA), and National Science Foundation (NSF) cumulatively awarded almost \$4 million in SBIR funding for projects involving SOFCs, PEM fuel cells, and hydrogen energy storage.

In addition, FTA awarded the Stark Area Regional Transit Authority (SARTA) in **OHIO** more than \$4 million to buy three American Fuel Cell Buses (AFCB).³⁶ When added to the seven fuel cell buses planned to be delivered by end of 2017, SARTA's fleet of 10 fuel cell buses will be largest U.S. deployment outside of California.

"With this funding, SARTA will be able to expand its growing fleet of zero emission buses and help reduce emissions in public transportation."

– [U.S. Sen. Sherrod Brown](#) (OH) speaking about FTA's LoNo Bus Program funding award for three fuel cell buses

See Appendix 2 for a detailed listing of federally-funded fuel cell and hydrogen projects over the last year (August 2015-July 2016). This includes awards in the following states: **ARIZONA, CALIFORNIA, COLORADO, CONNECTICUT, FLORIDA, HAWAII, ILLINOIS, MASSACHUSETTS, MICHIGAN, MINNESOTA, MISSOURI, NEW JERSEY, NEW MEXICO, NEW YORK, OHIO, OREGON, PENNSYLVANIA, SOUTH CAROLINA, TENNESSEE, TEXAS, UTAH, VIRGINIA,** and **WASHINGTON**.


Fuel Cell Power Generation

Fuel cells are a highly efficient, reliable alternative to conventional power generation. Fuel cells can be scaled from watts to multi-megawatts systems. These fuel cells provide clean, reliable primary or backup power to a variety of sites, including corporate and municipal facilities, and support critical infrastructure, such as police and fire stations, communications networks, railside equipment, and hospitals, at data centers processing credit card and other transactions, and other facilities. In several northeastern states, where powerful storms and inclement weather has crippled the electrical grid, utilities and municipalities are integrating fuel cells into microgrids capable of producing continuous power for essential services, like first responders, gas stations, senior centers, schools and emergency shelters. Businesses and municipalities are choosing fuel cells to enhance reliability, lower costs, reduce emissions and decrease water use. Fuel cells are ideal in these applications because of their attributes and the benefits provided (see the Benefits of Fuel Cells for Stationary Power chart, next page).


Since our last report, a number of customers have selected fuel cells from American manufacturers of stationary fuel cell systems. These large-scale fuel cells are sited at American municipalities and businesses and multi-MW orders are being exported to South Korea.

- Sunnyvale, **CALIFORNIA**-based Bloom Energy installed its Bloom Energy Servers at customer sites in California, Connecticut, and New York. Several are returning customers – IKEA, Morgan Stanley and Walmart.
- South Windsor, **CONNECTICUT**-based Doosan Fuel Cell America installed PureCell® Model 400 fuel cells at California State University, San Marcos and at Norco College in California. Doosan also received orders from two South Korean electric utilities for a combined total of 81 systems (35.8 MW) that will be produced at its Connecticut manufacturing facility.
- Danbury, **CONNECTICUT**-based FuelCell Energy commissioned a new fuel cell system at Santa Rita Jail in Alameda County, California – a returning customer that has operated a FuelCell Energy power plant since 2006. Several installations are also planned in Connecticut: a 5.6-MW fuel cell system to be located at Pfizer’s research facility in Groton, and a second, proposed Connecticut fuel cell at a brownfield site in the city of Bristol. FuelCell Energy also announced sales of 14 MW of fuel cell modules to its South Korean partner, POSCO Energy, in addition to monthly shipments to POSCO, totaling 33.6 MW in 2015, under an existing, multi-year contract.

Benefits of Fuel Cells for Stationary Power



Reliability	Fuel cells are extremely reliable and can either be connected to, or in parallel with, the electric grid. Fuel cells provide a constant power output that does not have the same voltage surges and sags as the electric grid.
Efficiency	Fuel cells operate at 40-60% efficiency and, when configured for combined heat and power (CHP), efficiency increases to above 90%.
Siting options	Because fuel cells are lightweight and quiet, they can be sited inside or outside, on rooftops or in underground parking garages.
Fuel choice	Fuel cells for primary or backup power can run on a range of fuels, including natural gas, hydrogen, or biogas. Hydrogen can be generated from renewable solar and wind electrolysis.
Runtime	Fuel cells deployed for backup power (cell towers, railroad signals, communications networks) or for off-grid or remote power sources (monitoring equipment, security/surveillance, energy exploration) can operate on hydrogen or methanol for days to weeks at a time, reducing trips to deliver fuel to diesel or propane generators or to replace spent batteries.
Energy Security	Fuel cells can run on natural gas, connecting to the resilient underground pipeline system. Fuel cells do not have to be connected to the electrical grid, allowing for distributed generation and less dependence on high voltage central power generation, which is vulnerable to attacks and natural disasters. Fuel cells aid critical communications networks, providing crucial connections and continuous power during outages from storms or other causes. Fuel cells are also rugged and can be sited in harsh terrain, extreme climates, and rural areas.



Less		
	Emissions	Hydrogen = zero emissions Natural gas = very low emissions, exempt from air permitting requirements in California
	Water use	Fuel cells operate in water balance, with most fuel cells only requiring less than a gallon per megawatt-hour (MWh).
	Footprint	For a comparable power output, fuel cells have a smaller physical footprint than solar.
	Burden on grid	Fuel cells can be configured to operate independent from, or parallel with, the grid.
	Noise	Fuel cells are very quiet, measured at approximately 60 decibels (dBa). Air pumps and/or fans are usually the only source of noise on a fuel cell power unit or vehicle.
	Red tape	Emissions from fuel cells are so low that some areas of the U.S. have exempted fuel cells from air permitting requirement.

Promoting Distributed Generation

Several states encourage the integration of fuel cell power generation to improve the resiliency of power generation, lessen the burden on the grid, and help meet emissions reduction goals. **CALIFORNIA**, **CONNECTICUT**, **NEW JERSEY** and **NEW YORK** have incentive programs focused on distributed generation and/or microgrids under which fuel cells are eligible. Thirty states include fuel cells among the eligible technologies under their Renewable Portfolio Standard (RPS).³⁷

Distributed (onsite) generation technologies help to improve the resiliency of power production and lessen the burden on an aging electric grid. They also help states achieve RPS goals that lower the carbon intensity of grid resources. Several states have recently issued clean energy procurements to help meet their RPS and include fuel cells or hydrogen in the definition of a clean or alternative fuel. Others have clean energy programs that provide incentives for stationary fuel cell installations. These states have become key areas where fuel cell manufacturers and customers are beginning to thrive. Since our last report:

- The **CALIFORNIA** Public Utilities Commission's Self-Generation Incentive Program (SGIP) 2016 Program, which includes electric-only or combined heat and power fuel cells, was opened to [application submissions](#) in February 2016. Since 2001, more than 400 fuel cell systems have been installed in California with SGIP support, making California the leading state for stationary fuel cell installations. The total SGIP fuel cell capacity is more than 175 MW, comprised of more than 40 MW of CHP fuel cell systems and almost 135 MW of electric-only fuel cells.
- In **NEW YORK**, NYSERDA made [\\$150 million in funding](#) available for large-scale renewable energy projects to help the state meet its goal of 50% renewable electricity by 2030. Fuel cells are included and contracts are awarded for a term of up to 20 years. The competitive solicitation's submission deadline was May 2016.
- New York reports that for every \$1 invested in NYSERDA Main Tier³⁸ projects, New York realizes \$3 in economic benefits.³⁹ More than \$3 billion of direct investment in the state is expected as a result of existing Main Tier projects in the form of jobs, payments to public entities, in-state purchase of goods and services and land leases, growth in the New York's clean energy economy and reduced emissions.⁴⁰
- In November 2015, **CONNECTICUT**, **MASSACHUSETTS** and **RHODE ISLAND** issued a [procurement](#) soliciting offers for clean energy and transmission to deliver clean energy. The request for proposals (RFP) led to 24 bids for projects, including a proposal for a 63-MW fuel cell power plant that will be located in **CONNECTICUT** (Beacon Falls Energy Park), which has already been approved by the Connecticut Siting Council.

- The **NEW JERSEY** Clean Energy Program's (CEP) Combined Heat & Power (CHP) Program offers incentives for fuel cell systems with heat recovery.

After being hit hard by storms, some Northeast states are looking to microgrids as a way to boost resiliency and ensure ongoing power. A microgrid is a small-scale power grid that can operate independently or in conjunction with the area's main electrical grid.⁴¹ Microgrids can bolster the main power grid during peak demand periods, ensure service in the case of emergency outages, and often involve multiple energy sources, including renewable power.

Several states include fuel cells in microgrid programs and projects.

CONNECTICUT, through its competitive [Microgrid Grant and Loan Program](#) began accepting Round 3 applications in December 2015. Connecticut also offers incentives via its [Low-Emission Renewable Energy Credits Program \(LREC\)](#), which enables participants to sell qualified Connecticut Class I renewable energy credits created from renewable projects to the local utility under a long-term contract.

These programs are having real impact. In April 2016, construction began on a microgrid in the Parkville neighborhood of Hartford.⁴² The City is working with Constellation, a subsidiary of Exelon Corporation, to install 800 kW of Bloom Energy fuel cells to provide all of the non-emergency power to a range of municipal facilities, including a library, senior center, and health center. During power outages, these sites will continue to run, and emergency power will also supply a gas station and grocery store. Excess electricity generated by the microgrid system will help reduce electricity costs at four local schools.

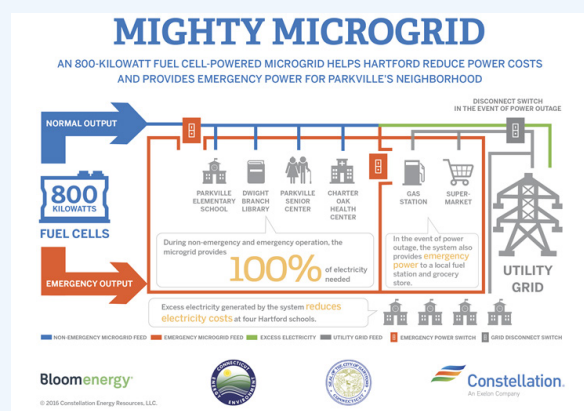
Also in Connecticut, a 1.4-MW fuel cell now supplies 80% of the University of Bridgeport's power needs to critical facilities such as residence halls, campus security, a dining hall, and student center. The savings extend to more than the 7,000 tons of CO₂, 64 tons of sulfur oxides (SO_x), and 28 tons of nitrogen oxides (NO_x), but also to cost savings – approximately 20% during normal operations. Since the fuel cell is configured for CHP, the waste heat is captured and used at three different locations on campus – to heat an Olympic-sized swimming pool, and for hot water and laundry in an apartment complex and dorms.

"The Connecticut LREC program has been very successful to improve the quality and number of proposals for fuel cell applications in Connecticut. The result has been lower cost applications and increased coordination with end users. The State of Connecticut and the public have benefited with improved environmental performance, increased energy reliability, and economic development associated with the manufacture and installation of fuel cell technology."

– Joel Rinebold, Director of Energy Initiative, Connecticut Center for Advanced Technology, Inc.

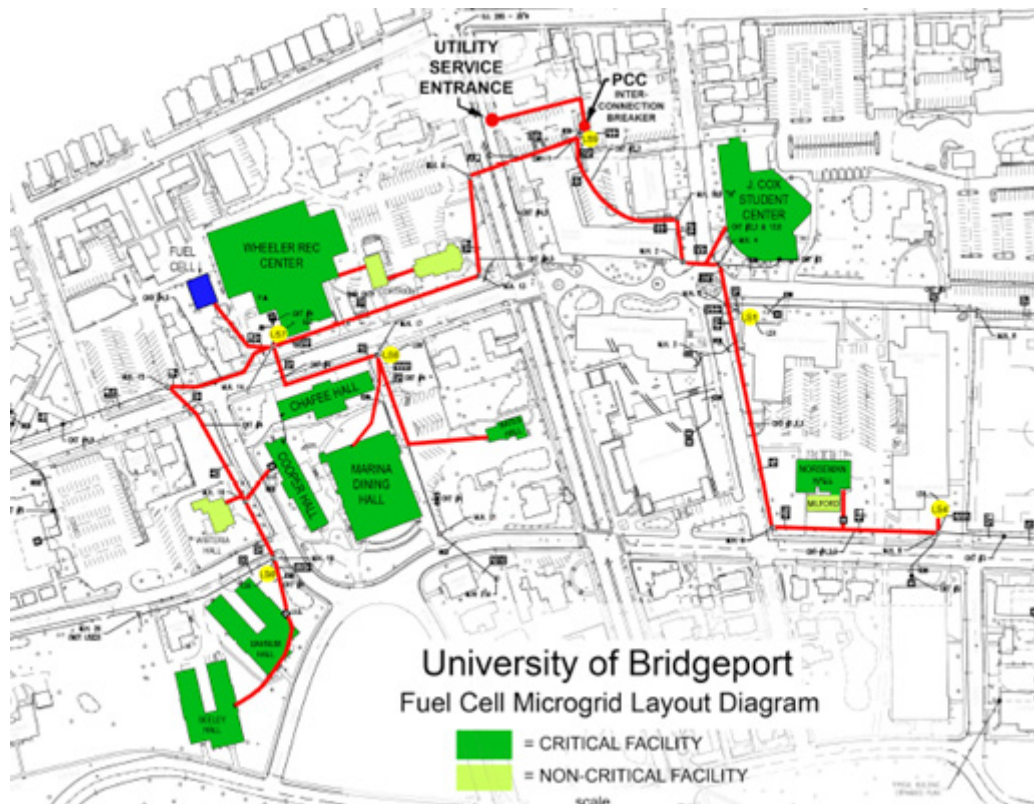
"The Parkville microgrid is a perfect example of the positive impact we can have on our communities and residents through innovative and creative approaches to the energy challenges we face. This microgrid will help reduce energy costs for the City of Hartford and its school system, in addition to providing power to maintain important services for people when the electric grid goes down. We are pleased that DEEP's microgrid grant program and other energy initiatives helped make this impressive project possible."

– [Robert Klee](#), Commissioner, CONNECTICUT Department of Energy and Environmental Protection (DEEP)



"When the power goes out elsewhere, our state-of-the-art microgrid will keep the power running at a senior center, library branch, school, health center, supermarket and gas station. In addition, the clean energy produced by the fuel cells will result in cost savings for the City of Hartford. That's a win-win for our city – and we hope to build on this model elsewhere in Hartford."

– Hartford, Connecticut, [Mayor Luke Bronin](#)



Red lines = electric wires, green boxes – connected to fuel cell

NEW YORK offers funding through the competitive [NY Prize](#) program. In April 2016, NYSERDA issued a competitive Stage 2 Design request for proposals (RFP). The objective of NY Prize is to promote the design and build of community microgrids that improve local electrical distribution system performance and resiliency in both a normal operating configuration as well as during times of electrical grid outages.

The **CALIFORNIA** Energy Commission (CEC) has also provided for two microgrids that include fuel cells:

- CEC provided nearly \$2 million in funding for the Santa Rita Jail’s microgrid project through its Public Interest Energy Research (PIER) program. The Santa Rita Jail is replacing a FuelCell Energy fuel cell system it had been operating since 2006 with a 1.4-MW fuel cell CHP system, also from FuelCell Energy. Operating in parallel with a solar array and a battery storage system, the fuel cell will supply approximately 60% of the jail’s total baseload power demand as well as 70% of the energy use. The excess heat from the fuel cells will be used for generating hot water.
- CEC’s Electric Program Investment Charge (EPIC) provided \$5 million in funding for a community microgrid that provides power to the Blue Lake Rancheria reservation and Red Cross safety shelter-in-place facilities.

Turning Brown into Green

Aside from the benefits that fuel cells provide in stationary applications, there is another advantage that makes the technology compelling from the public sector vantage point. Fuel cell systems are being installed on city-owned brownfield sites, where remediation can be assisted by funding from federal and state programs. Once revitalized, these sites generate tax dollars and in some cases, revenues for the local area.

The Environmental Protection Agency (EPA) defines a brownfield as redevelopment, expansion or reuse of property that may be complicated by the presence or potential presence of a hazardous substance, pollutant, or

contaminant. The EPA Brownfields program provides funding for various stages in the process – assessment, cleanup, and job training – as well as guidance on additional financing.⁴³

Many states also have brownfield redevelopment and reinvestment programs, and some, such as **CONNECTICUT**, are making sure fuel cells are part of the effort. The state was recognized by EPA as one of the most active and innovative states nationwide in the remediation and redevelopment of brownfields. Connecticut finds that for every dollar it invests in brownfield remediation, \$5.45 has been or will be invested by non-state partners.⁴⁴

In June 2016, Connecticut’s Department of Economic and Community Development awarded \$1.3 million to a proposed project in Bristol, remediating a city-owned brownfield site and installing a FuelCell Energy fuel cell on the rear portion of the site as well as commercial/mixed used development.⁴⁵

Earlier fuel cell projects on brownfield sites in Connecticut include the 14.9-MW FuelCell Energy installation in Bridgeport’s industrial area, a 2.8-MW FuelCell Energy system on a former landfill site in Bridgeport, and a proposed 63-MW energy park in Beacon Falls on a former sand and gravel mine. That project is working its way through the approval process but will utilize 11 acres of the site’s 25 acres. In comparison, to generate the same amount of power would require more than 300 acres of solar.⁴⁶

“Bristol brings a number of unique features, like location. One of our goals is to reutilize and reinvest where there are Brownfields. These are perfect for clean fuel cells that create power.”

– [Frank Wolak](#), Vice President, FuelCell Energy, speaking about a proposed multi-MW fuel cell system that would be located at a Bristol brownfield site

“First, it will bring in much-needed tax dollars. And, it’s a good fit for the spot. It’s being built on a piece of land not buildable for any other use. It will be less cost for cleanup because a lot of the contaminants in the soil will be covered with a concrete pad.”

– Bristol, Connecticut, Mayor [Ken Cockayne](#)

EXAMPLES OF U.S. STATIONARY FUEL CELL INSTALLATIONS AND ANNOUNCEMENTS SINCE THE LAST REPORT:

MULTIPLE STATES	Home Depot: multiple sites in CALIFORNIA, CONNECTICUT, NEW YORK (Bloom Energy)
CALIFORNIA	California State University , San Marcos (800 kW, Doosan Fuel Cell America)
	IKEA , four locations: Costa Mesa, Covina, East Palo Alto, and San Diego (Bloom Energy)
	Norco College , Riverside (400 kW, Doosan Fuel Cell America)
	Santa Rita Jail , Alameda County (1.4 MW, FuelCell Energy)
	Staples Center , Los Angeles (500 kW, Bloom Energy)
CONNECTICUT	Hyatt Regency Greenwich , Old Greenwich (500 kW, Bloom Energy)
	LeGrand North America , West Hartford (500 kW, Bloom Energy)
	Pfizer , Groton (5.6 MW, FuelCell Energy)
NEW YORK	Morgan Stanley , New York City (750 kW, Bloom Energy)
SOUTH CAROLINA	Midland County Public Schools (refurbished fuel cells)

Several of the above sites were supported by state polices, including California State University (CSU), San Marcos (SGIP); Norco College, California (SGIP); City of Bristol (Connecticut Department of Economic and Community Development); and Morgan Stanley (NYSERDA RPS Main Tier Program).

For more information on corporate customers of fuel cells, including the different applications and benefits, the [Business Case for Fuel Cells](#) report series provides a comprehensive overview.

State and Local Officials Sound Off on Recent Fuel Cell Projects

“Partnerships between the State and private sector have made New York a global leader in reducing greenhouse gases and advancing clean energy solutions, and will continue to play a vital role in transforming our energy system. This project is an example of how new and innovative technologies will help us achieve Governor Cuomo’s vision of an energy system that is cleaner, more resilient and more affordable for all New Yorkers.”

– [John B. Rhodes](#), President and CEO of NYSERDA, speaking about Morgan Stanley’s planned New York City fuel cell system

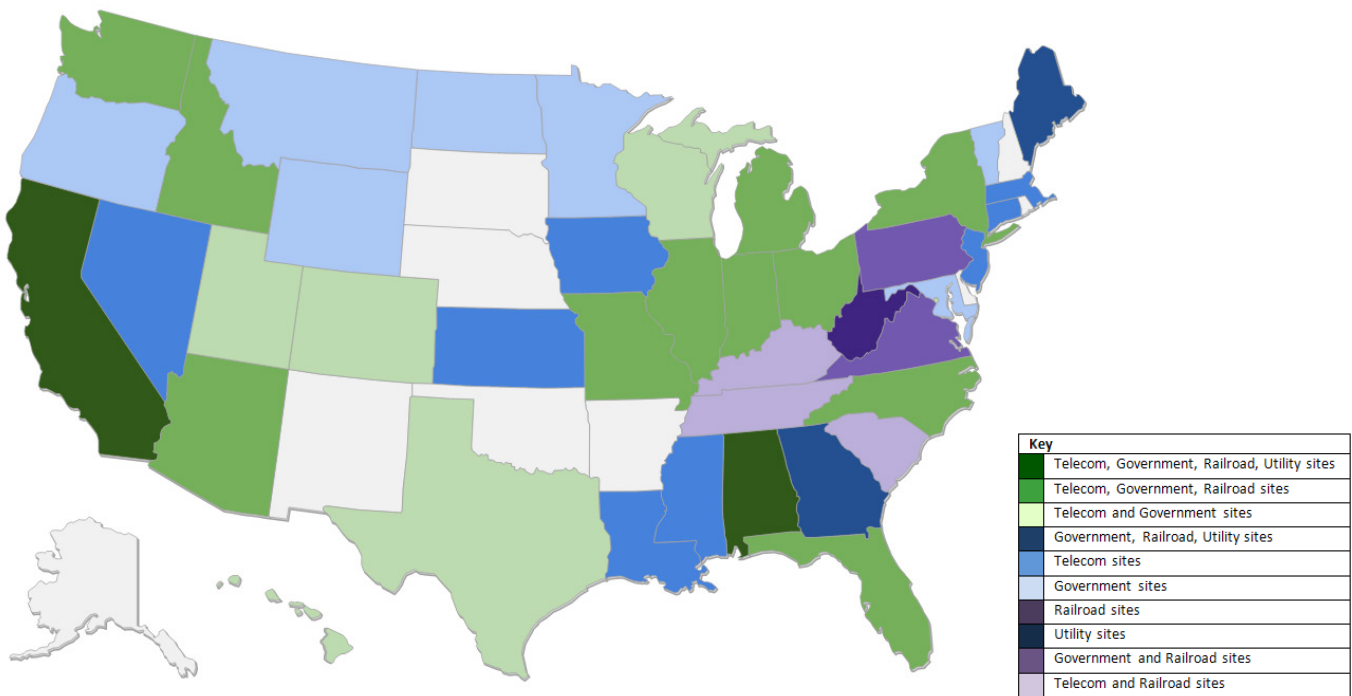
“Installing the fuel cell continues the Alameda County Board of Supervisors’ long standing commitment to environmental leadership through the adoption of clean, on-site power generation that delivers cost savings.”

– [Caroline Judy](#), Acting Director of the General Services Agency for Alameda County talking about the Santa Rita Jail fuel cell

“We are devoted to fostering environmental responsibility and sustainability among our student body, while controlling energy costs. Additionally, with the ongoing water shortage crisis in California, the fact that we’re now able to conserve water, compared to the grid generated energy, is an added benefit. Our partnership with Doosan will provide cleaner power, allowing us to take control of our college’s energy portfolio while minimizing water consumption on campus.”

– [Laurens Thurman](#), consultant of facilities planning and development for the Riverside Community College District, which oversees three campuses, including Norco College

Fuel Cell Backup Power Systems in United States



Map created by the Fuel Cell and Hydrogen Energy Association

Reliable Backup Power for Cellular and Critical Communication

With our increasing reliance on the internet, cell phones, and emergency communications, and the electricity needed to keep those networks running, reliable backup power is becoming more important than ever.

Hundreds of fuel cell systems are installed across the United States at a variety of sites – telecommunications towers, railroad switching and signal stations, government facilities and utility networks – to provide constant power in case of weather or other outages to the grid or communications lines. Fuel cells can operate independent of the electric grid and can be sited in remote areas, helping keep customers connected and keep critical communications running smoothly. Forty-one states have fuel cells installed in at least one of these sectors, with many hosting multiple sites serving two or more sectors, which are highlighted in the map on the previous page.

In late 2015, a Plug Power blog discussed how two rail customers, BNSF Railway (Forth Worth, **TEXAS**) and CSX (Jacksonville, **FLORIDA**), are investing in the company's GenSure (formerly ReliOn) hydrogen fuel cells for backup power for their rail-side equipment.⁴⁷

CSX Corporation first deployed a fuel cell backup system for its railway near its Jacksonville, **FLORIDA**, headquarters in 2010. In the next two years, the company expanded to 50 additional sites, including North Baltimore, **OHIO**, to provide communications backup service. CSX reports that in 2013, massive storms knocked out commercial power service in Northwest Ohio for more than 3 weeks. The sites with battery backup needed support from portable generators, but the North Baltimore fuel cells continued to provide power without interruption. CSX subsequently purchased 140 additional fuel cell systems.⁴⁸



Plug Power fuel cell at railway site

In February 2016, fuel cell manufacturer Ultra Electronics USSI (Columbia City, **INDIANA**) announced that it was awarded a follow-on contract for a large volume of fuel cell systems from strategic partner RedHawk Energy Systems, LLC (Pataskala, **OHIO**). The fuel cell systems provide 24/7 extended run back-up power for railway signals and crossings using commercially-available propane.⁴⁹

Telecommunications companies also require reliable power to keep cell phone towers up and running. Fuel cells are being adopted globally to provide primary power in remote areas, or backup power that keeps systems running during inclement weather events that bring grids down. Fuel cells are not only highly reliable, but also operate longer than battery or diesel-fueled backup power sources and require little maintenance.

Folsom, **CALIFORNIA**-based fuel cell manufacturer Altery Systems reported that its fuel cell systems, installed at multiple cellular towers in the Caribbean, provided continuous power through Category 4 Hurricane Joaquin (September 28-October 15, 2015), despite the 130 mile per hour winds and storms.⁵⁰

"In the most extreme conditions, Altery fuel cells provided the most reliable, continuous backup power during Hurricane Joaquin while other solutions we service (i.e. batteries and generators) had multiple outages."

– [Rey Smith](#), CEO, Island Alternative Power Solutions (IAPS)

Off-Grid Power Resources: Fuel Cells Light the Way at Super Bowl City

Alteryg Systems donated several of its portable fuel cell-powered generators for use in lighting the streets and stages of Super Bowl City during Super Bowl 50 (Santa Clara, CALIFORNIA), held in February 2016. Unlike diesel generators, fuel cells operate quietly, which allowed Alteryg’s systems to be sited in, or adjacent to, food and beverage areas without disturbing patrons.



“We were thrilled that Alteryg supported our low carbon goals and supplied a large percentage of our hydrogen fuel cell power in Super Bowl City. We were able to get nearly 100% of our energy without using any dirty diesel.”

– [John Mitchell](#), Director of Event Productions, San Francisco Bay Area Super Bowl 50 Host Committee

“The generators powered by Alteryg’s fuel cells gave us the opportunity to place power sources and area lighting as close as possible with minimal to zero impact on the area closest to the generators. While traditional diesel powered light towers provide ample lighting, they are noisy and are not something we can place near to food and beverage areas. Alteryg’s generators could be placed right next to and in one case even integrated into a bistro seating area, all the while people could have normal conversations right next to the generator, and in some cases they couldn’t even tell it was on.”

– [Jude Freeman](#), Event Logistics for Sitaline Productions

Repurposed Fuel Cells Get a Second Life

Columbia, SOUTH CAROLINA’s, Richland School District Two will receive a refurbished fuel cell to serve as a backup power system for the Richland Two Institute of Innovation (R2i2).⁵² The fuel cell is one of 10 removed from Fort Jackson after completing a five-year DOE demonstration project that was managed by the South Carolina Research Authority (SCRA). Following the demo, SCRA took custody of the fuel cell units and those suitable for service were refurbished through funding from the South Carolina Fuel Cell Collaborative. Additional refurbished units will be installed at other Midlands schools. The units are expected to provide five or more years of backup power.



Support for FCVs and Hydrogen Stations

Many U.S. states are looking at growing deployments of zero-emission vehicles (ZEVs), including FCVs, to lower greenhouse gas emissions from the transport sector. Nationwide, states are set to play a major role in providing incentives and policies that encourage the use of FCVs and the development of public hydrogen fueling stations and corridors. Some states are working individually, while others are working together through a multi-state ZEV initiative and via participation in H2USA, a public-private collaboration to promote the commercial introduction and widespread adoption of fuel cell electric vehicles across America.

H2USA

H2USA brings industry, government, National Laboratories, and other stakeholders together to work towards the widespread commercial introduction and adoption of fuel cell vehicles. H2USA's working groups address station locations, codes and standards, investment and funding, and market acceleration. Several states participate at either the governmental, association, or organizational level, including **CALIFORNIA, HAWAII, MASSACHUSETTS, OHIO, and SOUTH CAROLINA**, and through the Northeast States for Coordinated Air Use Management (NESCAUM), **NEW YORK, NEW HAMPSHIRE, RHODE ISLAND, VERMONT, CONNECTICUT, MAINE** and **NEW JERSEY**.

One of the group's recent accomplishments was the Hydrogen Station Equipment Performance (HyStEP) device, which began validation at **CALIFORNIA** refueling stations, reducing the time to commission new stations from months to just one week. The device was developed by DOE's Sandia National Laboratories and NREL, both H2USA members, and was funded by DOE as part of the Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) project, which was established by DOE's FCTO directly in support of H2USA.

Zero-Emission Vehicle States

In 2013, the governors of **CALIFORNIA, CONNECTICUT, MAINE, MARYLAND, MASSACHUSETTS, NEW JERSEY, NEW YORK, OREGON, RHODE ISLAND, and VERMONT** signed a MoU committing to deploying 3.3 million electric vehicles by 2025, including FCVs (**NEW JERSEY** and **MAINE** have also adopted California's ZEV standards, but are not signatories to the MoU). NESCAUM – comprised of the air pollution regulatory agencies in **CONNECTICUT, MASSACHUSETTS, MAINE, NEW HAMPSHIRE, NEW YORK, NEW JERSEY, RHODE ISLAND** and **VERMONT** – serves as facilitator and technical adviser to the Multi-State ZEV Task Force. In November 2015, NESCAUM signed a MoU with the U.S. Department of Energy, committing to working together to accelerate the deployment of ZEVs and ZEV infrastructure.

Since our last report, the ZEV states have taken a [range of actions](#) to support the deployment of FCVs.

CALIFORNIA

- In November 2015, the Governor's Office of Business and Economic Development [published](#) a hydrogen station permitting guidebook highlighting best practices for planning, permitting, and opening a hydrogen fueling station.
- In January 2016, the California Air Resources Board (CARB) granted [contingent certification](#) for renewable hydrogen generation using fuel cells at wastewater treatment facilities under the Low Carbon Fuel Standard (LCFS).⁵³ Each kilogram of renewable hydrogen generated and supplied for vehicle fueling is eligible for a LCFS credit that can be sold or traded to offset petroleum fuel usage.

Most automakers have placed fuel cell vehicles (FCVs) with customers, and many plan to introduce FCVs to the early commercial market in the 2015-2017 timeframe. By 2020, automakers expect to place tens of thousands of fuel cell electric vehicles in the hands of California consumers. Today, about 300 FCVs have been placed on California's roads and fill at public and private hydrogen stations in the state. These vehicles have either been leased in Southern California or have joined fleet programs. As the number of FCVs in California increases over the next 5 to 10 years, California is working hard to ensure hydrogen is easily available to drivers.

– [California's Drive Clean Program](#)

- In February 2016, the California Energy Commission [awarded](#) a \$220,000 Operation and Maintenance grant to industrial gas supplier Linde as part of the 6th notice of proposed awards under the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). The funding will go to upgrade and support a hydrogen fueling station in San Ramon.
- As of July 31, 2016, the Air Resources Board (ARB) Clean Vehicle Rebate Project (CVRP), which promotes the purchase of battery electric, plug-in hybrid electric, and fuel cell vehicles, has [issued](#) 250 FCV rebates, totaling \$1,174,000. FCVs are eligible for a \$5,000 rebate. In June, CRVP reported that funding was exhausted and that all applications submitted after June 10, 2016 would be placed on a rebate waitlist.

CONNECTICUT

- The Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) program offers rebates for Connecticut residents who purchase or lease a new eligible FCV with a manufacturer's suggested retail price (MSRP) of no more than \$60,000. This point-of-sale rebate can be obtained at the dealer when purchasing or leasing an eligible vehicle. As of July 1, 2016, the FCV rebate was [increased](#) to \$5,000, from \$3,000. The CHEAPR program also received an additional \$1 million in funding in 2016, allowing it to continue issuing rebates for an additional year.
- In June 2016, Connecticut's governor [signed](#) a bill to prepare electric distribution companies, municipalities, public and private merchants and electrical contractors for the presence and operation of electric, zero-emission and fuel cell vehicles in the state. The new law permits parking of hydrogen fuel vehicles under grade level and makes changes regarding labeling of vehicles that carry pressurized gas as fuel.

"Decreasing our reliance on fossil fuels from overseas is a critical goal for national security and our environment. The integration of electric vehicles onto our roads will reduce carbon emissions into our air, benefitting our planet for future generations."

– [U.S. Congressman Joe Courtney \(CT\)](#) speaking about the state's CHEAPR Program

NEW JERSEY

- In January 2016, the New Jersey Senate passed [legislation](#) to establish a Clean Vehicle Task Force to evaluate the use of low- and zero-emission vehicles in New Jersey, including FCVs. The bill, however, was not acted on by the Governor by the end of the session (pocket veto). The state does offer a [sales tax exemption](#) for ZEVs. For 2016, qualifying vehicles include the Toyota Mirai and the Hyundai Tucson Fuel Cell.

NEW YORK

- In 2016, as part of the [Clean Fleets New York](#) pilot program, New York's Department of Environmental Conservation, NYPA, NYSERDA, among other agencies and as part of a pilot program, will ensure that at least half of new, administrative-use vehicles will be ZEVs, including FCVs. These agencies will explore ZEV acquisition models, such as leasing, to take advantage of federal tax incentives and lifecycle savings to reduce costs. This model will inform procurement decisions throughout New York's state agencies.
- To meet transport-related GHG emissions reduction goals, New York City announced in December 2015 that it will adopt a portfolio of strategies that include cleaner fueling technologies, including hydrogen. The [NYC Clean Fleet](#) project aims to reach a 50% reduction in greenhouse gas emissions from fleet operations below 2005 levels by 2025 and an 80% reduction by 2035.

OREGON

- Oregon's new [Clean Fuels Program](#) aims to reduce lifecycle greenhouse gas emissions gases from Oregon's transportation fuels by 10% over a 10-year period. Regulated parties – importers who bring gasoline, diesel, ethanol, or biodiesel from locations outside of the state – must comply with the program by blending in low-carbon biofuels, or purchasing credits from registered credit generators who provide clean fuels whose carbon intensity is lower than the standard for the gasoline or diesel they substitute for. Hydrogen is included in this list of qualifying clean fuels.

The above actions can serve as models for other states to engage in preparation for future FCVs. In fact, several non-ZEV states, as well as municipalities, have recently taken similar actions. These are highlighted in the sections below.

Actions by Non-ZEV States

COLORADO

- A new [measure](#), signed by Colorado’s governor in March 2016, requires that, by January 1, 2017, the director of the Division of Oil and Public Safety must promulgate rules concerning retail hydrogen fuel for vehicles, including rules relating to inspections, measurement, and specifications. The bill also amends the state’s definition of “fuel products” to include hydrogen.

NEBRASKA

- In January, Nebraska [launched](#) the Clean-burning Motor Fuel Development Rebate Program to provide rebates on qualified clean-burning motor vehicle fuel property – including hydrogen fuel cells. FCVs are eligible if they are purchased; leased vehicles are not eligible. Rebates for the portion of the purchase price of a motor vehicle attributable to the cost of the fuel tank, fuel lines, and exhaust system is 50% of that cost or \$4,500, whichever is less. The rebate program is administered by the Nebraska Energy Office.

PENNSYLVANIA

- Pennsylvania’s [Alternative Fuels Incentive Grant Program](#) offers a \$1,000 rebate on the purchase of a hydrogen and/or fuel cell vehicle.

WASHINGTON

- Washington State [modified](#) the retail sales and use tax exemption criteria for certain clean alternative fuel vehicles, effective July 1, 2016, which include new passenger cars, light duty trucks, and medium duty passenger vehicles. The legislature crafted the modifications to increase the use of clean alternative fuel vehicles by extending the existing sales and use tax exemption on certain vehicles in order to reduce the price charged to customers, and includes vehicles powered by hydrogen. The exemption is applicable for up to \$32,000 of a vehicle’s selling price, or the total lease payments made plus the selling price of the leased vehicle if the original lessee purchases the leased vehicle before the expiration of the exemption. New or leased vehicle purchases are not exempt from sales tax if, at the time of sale or leasing, the lowest manufacturer’s suggested retail price for the base model is more than \$42,500.

“As a leader in making cities more sustainable, we’re proud to implement new technology that reduces our impact on the environment.”

– [Long Beach Mayor Robert Garcia](#), speaking of the city’s new Toyota Mirai FCV



Photo source: City of Long Beach



Photo source: Sacramento County

Municipal Activities

The Genesee Region Clean Communities Coalition offered [grant funding](#) under Round 2.0 of the Congestion Mitigation & Air Quality (CMAQ) program. This six-county area comprises the **Rochester, NEW YORK** Nonattainment Area (CMAQ Eligibility Area). The objective of the program is to assist in the purchase and/or conversion of fleet vehicles to alternative fuels to support alternative fuel vehicle deployment. A total of \$1 million in funding was available for this round of the program, with future rounds anticipated if additional funds become available. Hydrogen vehicles are eligible for funding.

Long Beach, CALIFORNIA, recently acquired a Toyota Mirai. The FCV will be tested for six months as part of the City’s Motor Pool to determine its

practicality for further use and, after the pilot, the Mirai will be placed in several departments for more testing and feedback.⁵⁴

Sacramento County, CALIFORNIA, also acquired four Mirais in the city's fleet and plans to lease six more.⁵⁵

Commercial Hydrogen Initiatives

State efforts to prepare for FCVs, such as the policies and incentives being enacted in **CALIFORNIA** and in the **NORTHEAST**, combined with investments by commercial companies, are bringing FCVs and public hydrogen fueling stations to these states.

Toyota and Honda, for example, are providing funds to aid in public hydrogen station development in **CALIFORNIA**.

In April 2016, industrial gas company Air Liquide announced plans for four public hydrogen fueling stations in the northeast, the first of 12 hydrogen stations that will be deployed through the company's collaboration with Toyota Motor Sales USA, Inc. The initial network of hydrogen stations will span approximately 300 miles across five states (**CONNECTICUT, MASSACHUSETTS, NEW JERSEY, NEW YORK, and RHODE ISLAND**) and support the introduction of FCVs on the East Coast.⁵⁶ The stations are slated to open to the public by early 2017. The first four stations will be located in:

- Hartford, **CONNECTICUT**
- Braintree, **MASSACHUSETTS**
- Mansfield, **MASSACHUSETTS**
- Bronx, **NEW YORK**

Fuel Cell Buses

New technologies are evolving to replace diesel-powered transit buses, including fuel cell buses (FCBs) that reduce vehicle noise, improve fuel economy, and lower greenhouse gas emissions. The FTA's National Fuel Cell Bus Program, a cooperative initiative between government and industry, is working to advance commercialization of fuel cell technology in transit buses. Grant funding is provided through FTA's Low or No Emission Vehicle Deployment Program (LoNo Program) to purchase or lease the buses, with a requirement that at least half of the funding be provided through local and private contributions.

In April 2016, **OHIO**'s Stark Area Regional Transit Authority (SARTA) received more than \$4 million from FTA's LoNo program to purchase three FCBs. Also in April, SARTA was awarded \$1 million in state funding from the [Ohio Diesel Emission Reduction Grant Program](#) to purchase a fuel cell transit bus to replace an aging diesel bus. These additions will give SARTA – which had previously ordered seven fuel cell buses with FTA's assistance – the largest fuel cell bus fleet in the country, outside of **CALIFORNIA**.

New Flyer of America (headquartered in Canada, with facilities in the U.S.) conducted the inaugural road demonstration of its Xcelsior XHE60 heavy-duty articulated, 60-foot fuel cell transit bus in April 2016. The bus will be operated in revenue service by **CALIFORNIA**'s AC Transit for 22 months following completion of a comprehensive evaluation at the FTA's test facility in **PENNSYLVANIA**. After the testing, New Flyer intends to offer the Xcelsior FCBs to customers throughout the U.S. and Canada.

"Honda, Worthington Industries, LG Fuel Cell Systems, Swagelok and other Ohio companies as well as universities including Stark State, OSU and Case Western Reserve, are heavily involved and invested in fuel cell-related manufacturing and R and D projects. That means the federal and state dollars we've received will do more than put environmentally friendly buses on the road, they're going to help fuel Ohio's economy well into the future."

– [SARTA CEO and Executive Director Kirt Conrad](#)



Image source: SARTA

In July 2016, **CALIFORNIA**'s South Coast Air Quality Management District approved \$1 million for 10 FCBs to be operated in transit service by the Orange County Transportation Authority (OCTA, which serves Anaheim, Santa Ana and surrounding cities) by late 2017.⁵⁷ OCTA's FCB deployment is part of an earlier (April 2016), \$22 million funding award from CARB for the deployment of 20 FCBs in **CALIFORNIA**, along with hydrogen fueling infrastructure. The remaining 10 buses will be operated by AC Transit, which serves the East Bay area from San Pablo to San Leandro. CARB awarded the funding to the Center for Transportation and the Environment (Atlanta, **GEORGIA**), which is responsible for developing and deploying the bus projects.⁵⁸

In August 2015, AC Transit reported that one of its current FCBs reached a milestone: 20,000 hours of continuous operation. AC Transit deployed its first fuel cell bus in 2001. From March 2006 through mid-2010, AC Transit operated three fuel cell buses, logging over 270,000 miles and carrying over 700,000 passengers, while achieving significantly greater overall energy efficiency than diesel buses. Today AC Transit operates 12, third-generation FCBs on regular routes. The vehicles have cumulatively logged more than 150,000 hours of service. AC Transit's HyRoad fuel cell bus program is supported entirely by grants from the CEC, CARB, Bay Area Air Quality Management District, Metropolitan Transportation Commission, and the FTA.

"The fuel cell bus is a workhorse, quietly and cleanly logging thousands of passenger miles over the years and still going strong. CARB's strategic investment in this demonstration project has shown that hydrogen fuel cells are a viable option for transit agencies in tough, demanding applications. I look forward to many more of these buses rolling out across the state as California communities strive to reach our clean air and climate protection goals."

– California Air Resources Board (CARB) Chair [Mary D. Nichols](#), speaking of AC Transit's FCB milestone

Fuel Cells for Material Handling

Companies with distribution centers and warehouses continue to deploy fuel cell-powered material handling equipment (MHE) to improve operational performance and reduce costs.

Today, more than 11,000 fuel cell-powered forklifts are operating in North America, located at facilities in more than 20 U.S. states: **ALABAMA, CALIFORNIA, COLORADO, FLORIDA, GEORGIA, ILLINOIS, INDIANA, KENTUCKY, LOUISIANA, MASSACHUSETTS, MARYLAND, MINNESOTA, MISSOURI, NORTH CAROLINA, NEW JERSEY, NEW YORK, OHIO, PENNSYLVANIA, SOUTH CAROLINA, TENNESSEE, TEXAS, VIRGINIA,** and **WISCONSIN**.⁵⁹

Familiar companies using fuel cells for distribution operations include Ace Hardware, Coca-Cola, FedEx, Home Depot, Newark Farmer's Market, Kroger, Lowe's, Proctor & Gamble, Sysco, Walmart, Wegmans, and more, and manufacturing facilities operated by BMW, Honda, and Volkswagen. Many of these companies have multiple sites around the country using fuel cells in MHE fleets, or in some cases, powering the entire fleet.

With the demonstrated success of fuel cell-powered MHE in the U.S., interest is also growing in Europe, helping boost manufacturing operations and sales from U.S.-based fuel cell companies. Plug Power recently received orders for several hundred fuel cells from companies in France and Belgium for use in warehouse operations.

Conclusion

Fuel cells are already playing an important role in enhancing our nation's energy security while boosting manufacturing, exports and job creation. The U.S. is the world leader in several market areas, with both manufacturing and installations/deployments, including large-scale stationary, material handling equipment, and backup power for telecommunications and other uses.

As the technology enters new markets and existing ones continue to grow, the U.S. fuel cell and hydrogen energy industry is expected to expand its reach to not only stack and system developers, but supply chain, integrators, repair and maintenance, sales and more.

State and federal support has been key to ensuring this role in the world's energy landscape and, as the industry continues to mature and widen, fuel cells are beginning to pay back this investment and then some.

For more information on fuel cells and hydrogen, and the fuel cell industry, in your state, across the U.S., and around the world, please visit:

- [U.S. Department of Energy Fuel Cell Technologies Office](#)
- [Fuel Cell and Hydrogen Energy Association](#)

Appendix 1: States Index

The following table highlights the section of the report in which each state appears.

State	Fuel Cell Deployments on the Rise	Top Fuel Cell States	U.S. Jobs and the Economy	Federal Support for U.S. Technologies	Fuel Cell Power Generation	Support for FCVs and Hydrogen Stations	Fuel Cells for Material Handling
Alabama							X
Alaska							
Arizona				X			
Arkansas							
California	X	X	X	X	X	X	X
Colorado		X	X	X		X	X
Connecticut	X	X	X	X	X	X	
Delaware	X						
Florida			X	X	X		X
Georgia			X			X	X
Hawaii		X		X		X	
Idaho							
Illinois				X			X
Indiana					X		X
Iowa							
Kansas							
Kentucky							X
Louisiana							X
Maine			X			X	
Maryland						X	X
Massachusetts		X	X	X	X	X	X
Michigan			X	X			
Minnesota			X	X			X
Mississippi							
Missouri				X			X

Montana							
Nebraska			X			X	
Nevada							
New Hampshire			X			X	
New Jersey		X	X	X	X	X	X
New Mexico				X			
New York		X	X	X	X	X	X
North Carolina							X
North Dakota							
Ohio		X		X	X	X	X
Oklahoma							
Oregon				X		X	
Pennsylvania			X	X		X	X
Rhode Island		X	X		X	X	
South Carolina				X	X	X	X
South Dakota							
Tennessee			X	X			X
Texas			X	X	X		X
Utah				X			
Vermont			X			X	
Virginia				X			X
Washington			X	X		X	
West Virginia							
Wisconsin							X
Wyoming							

Appendix 2: Examples of Federal Funding Awards

Examples of Federal Funding Awards Since Last Report

Award amounts are rounded

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
DEPARTMENT OF ENERGY					
ARIZONA	Tucson	Amsen Technologies LLC	\$0.15 million	Small Business Vouchers Pilot Round 1	Testing new fuel cell membrane designs with potential to reduce manufacturing costs – Los Alamos National Laboratory.
			\$0.15 million	FY16 SBIR Basic Energy Sciences (BES) Phase I Release 1 Award	Will develop a new low-cost, proton-conducting membrane for intermediate-temperature fuel cells based on a novel composite approach, which encompasses both the development of new, highly proton-conducting ionomers and the integration of an innovative membrane support.
CALIFORNIA	Berkeley	Lawrence Berkeley National Laboratory	\$0.15 million	Technology Commercialization Fund (TCF) Award	Flame-powered SOFC generators.
	Folsom	Altery Systems, Inc.	\$0.15 million	Small Business Vouchers Pilot Round 1	Improving fuel cell efficiency through modeling thermal performance – Sandia National Laboratories.
	Livermore	Lawrence Livermore National Laboratory (LLNL)	\$0.43 million	TCF Award	Cryo-compressed hydrogen tank technology in an internal combustion engine application. Joint project with GoTek Energy, Inc. of Oak View, California.
	Livermore	Sandia National Laboratories	Not available (N/a)	DOE Funding Opportunity Announcement	Will investigate and demonstrate a laboratory scale two-stage metal hydride-based hydrogen gas compressor.
	Newark	KWJ Engineering	\$0.2 million	Small Business Vouchers Pilot Round 1	Improving hydrogen sensors to enhance fuel infrastructure safety – Los Alamos National Laboratory/National Renewable Energy Laboratory.

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
CALIFORNIA (con't)	San Diego	General Engineering & Research LLC	\$0.15 million	FY16 STTR EERE Phase I Release 2 Award	One major inhibitor to a hydrogen society is economical hydrogen liquefaction systems to support safe storage and transportation of this fuel. Development of commercially available low cost magnetocaloric materials for magnetic refrigeration systems would enable a highly efficient and economical solution to support hydrogen liquefaction infrastructure.
	San Francisco	City of San Francisco	Part of a \$4.75 million award for fuel cell projects (<i>two awardees</i>)	Climate Action Champions Program	The San Francisco Department of the Environment will conduct comprehensive training and educational activities for hydrogen and fuel cell stakeholders throughout the Bay Area. A key goal is to harmonize local regulations and building codes to ease siting and construction of hydrogen fueling stations while reducing the cost and complexity of FCVs for the community through regional education and outreach.
	San Jose	PolarOnyx, Inc.	\$0.14 million	FY16 SBIR BES Phase I Release 1	Direct 3D femtosecond laser manufacturing of SOFC.
	Torrance	US Hybrid Corp.	\$3 million	DOE FCTO Funding Award	Northeast demonstration and deployment of FC-e-NV200.
	Valencia	Electricore, Inc.	\$1.3 million	DOE FCTO Funding Award	Innovative advanced hydrogen mobile fueler.
COLORADO	Boulder	Element One, Inc.	\$0.1 million	Small Business Vouchers Pilot Round 1	Development and testing of low-cost hydrogen leak detection, working with the National Renewable Energy Laboratory (NREL).
	Golden	National Renewable Energy Laboratory	\$3 million	DOE FCTO Funding Award	Extended surface electrocatalyst development.

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
CONNECTICUT	Bethel	Sonata LLC	\$1 million	FY16 SBIR BES Phase II Release 1 Award	Novel surface-functionalized powders for SOFCs
	Danbury	FuelCell Energy	N/a	DOE Funding Opportunity Award	Will demonstrate the potential of solid oxide electrolysis cell (SOEC) systems to produce hydrogen at a cost of \$2 per kilogram.
	East Hartford	UTRC	N/a	Fuel Cell Consortium for Performance and Durability (FC-PAD) Award	To develop more durable cell electrodes to lower the cost and improve the performance of PEM fuel cells.
	North Haven	Precision Combustion, Inc.	\$0.15 million	FY16 SBIR EERE Phase I Release 2 Award	High efficiency reformer for hydrogen production
			\$1 million	FY16 SBIR EERE Phase II Release 2 Award	Onboard implementation of an ultra-compact hydrogen generator for efficiency and emissions benefits in internal combustion engines.
	Wallingford	Proton OnSite	\$2.5 million	ARPA-E OPEN 2015 Award	To develop a hydrogen-iron flow battery that can generate hydrogen for FCVs and also store energy on the electric grid. This dual -purpose device can be recharged either using grid electricity or through photoregeneration by exposure to sunlight.
			\$1 million	FY16 SBIR BES Phase II Release 1 Award	Will work toward commercializing the first alkaline membrane-based water electrolysis product through the use of high efficiency, non-noble metal electrocatalysts and other advanced, low cost materials.
	East Hartford	Sustainable Innovations LLC	\$0.2 million	Small Business Vouchers Pilot Round 1	Developing a fuel contamination detector to ensure quality at hydrogen refueling stations, working with Los Alamos National Laboratory (LANL).
			\$1 million	FY16 STTR EERE Phase II Release 1 Award	Teamed with the University of Connecticut to develop an innovative multi-channel hydrogen fuel quality monitor to detect multiple impurities at low levels in hydrogen.

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
FLORIDA	Rockledge	Mainstream Engineering Corporation	\$1 million	FY16 SBIR EERE Phase II Release 2 Award	Cross-polarized near-UV/Vis detector for in-line quality control of PEM materials
HAWAII	Honolulu	University of Hawaii, Manoa	N/a	Hydrogen Materials-Advanced Research Consortium (HyMARC) Award	To investigate magnesium boride etherates as reversible hydrogen storage materials with properties that are vastly improved over unsolvated magnesium boride.
ILLINOIS	Argonne	Argonne National Laboratory	N/a	HyMARC	To develop a new class of hydrogen storage materials composed of nanoparticles of complex metal hydrides wrapped in sheets of graphene for improved onboard hydrogen storage.
	Carbondale	Midwest Energy Group	\$0.1 million	Small Business Vouchers Pilot Round 1	Development and evaluation of perfluorinated electrolytes, working with NREL.
	Chicago	Illinois Institute of Technology	\$3 million	DOE FCTO Funding Award	Corrosion-resistant non-carbon electrocatalyst supports for PEFCs
MASSACHUSETTS	Newton	Giner, Inc.	\$0.15 million	FY16 STTR BES Phase I Release 1 Award	Will develop novel hydrocarbon-based ionomeric membranes with high conductivity and mechanical strength for use in high-temperature fuel cell applications.
			N/a	DOE Funding Opportunity Award	Will demonstrate a cost-effective method for compressing hydrogen while eliminating the need for mechanical compressors which can have significant reliability issues.
			N/a	DOE Funding Opportunity Award	Will develop high temperature alkaline water electrolyzers with improved electrical efficiency at a reduced cost.
	Waltham	Ivys, Inc.	\$2 million	DOE FCTO Funding Award	Advancing hydrogen dispenser technology by using innovative intelligent networks.
	Westwood	Acumentrics	—	—	See NETL listing (Pennsylvania).

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
MICHIGAN	Pontiac	General Motors LLC	\$3 million	DOE FCTO Funding Award	Highly-accessible catalysts for durable high-power performance.
			N/a	FC-PAD	To employ both experimental and modeling approaches to study the effect of operating conditions on degradation, as well as the ways membranes fail, to improve overall performance of low-platinum group metal electrodes.
MINNESOTA	St. Paul	3M	\$3 million	DOE FCTO Funding Award	Highly active, durable, and ultra-low PGM NSTF thin film ORR catalysts and supports.
			N/a	FC-PAD	Integrating novel electrode ionomers with nanostructured thin film low-platinum group metal electrocatalysts in powder form to develop an improved cathode-coated membrane and electrode structure in the fuel cell.
MISSOURI	St. Louis	University of Missouri, St. Louis	N/a	HyMARC	To use a novel approach to stabilize unstable metal hydrides with sufficient storage capacities, and render reversible stable high capacity hydrides that are irreversible in the bulk, resulting in a high-capacity material with kinetics suitable for onboard hydrogen storage.
NEW JERSEY	Piscataway	NEI Corp.	\$0.15 million	FY16 SBIR BES Phase I Release 1 Award	Novel nanocomposite polymer electrolyte membranes for fuel cells.
	Piscataway	Structured Materials Industries, Inc.	\$1 million	FY16 SBIR BES Phase II Release 1 Award	Fluidized bed production of surface functionalized powders for SOFC cathodes
	Princeton	TreadStone Technologies	\$0.1 million	Small Business Vouchers Pilot Round 1	Novel, lower-cost coating for fuel cell metal bipolar plates, working with LANL and Oak Ridge National Laboratory.

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
NEW MEXICO	Albuquerque	Pajarito Powder, LLC	\$2.8 million	DOE ARPA-E OPEN 2015 Awards	To develop a reversible hydrogen electrode that would enable cost-effective hydrogen production and reversible fuel cells
	Santa Fe	Southwest Sciences, Inc.	\$1 million	FY16 SBIR BES Phase II Release 1 Award	Aims to develop a laser-based instrument for the detection of hydrogen contaminants at fuel stations to prevent fouling of vehicular fuel cells.
NEW YORK	Schenectady	Automated Dynamics	\$1.5 million	DOE FCTO Funding Award	Continuous fiber composite electrofusion couplers.
	Ithaca	City of Ithaca	\$0.3 million	DOE FCTO Funding Award	Ithaca, NY-an exemplary Climate Community of Excellence for the Northeastern U.S.
	Upton	Brookhaven National Laboratory (BNL)	\$0.1 million	TCF Award	Direct fabrication of fuel cell electrodes by electrodeposition of high-performance core-shell catalysts.
			\$0.1 million	TCF Award	Nitride-stabilized Pt core-shell electrocatalysts for fuel cell cathodes.
OHIO	Canton	LG Fuel Cells, Inc.	—	—	See PNNL listing (Washington state).
	Columbus	pH Matter LLC	\$1 million	FY16 SBIR BES Phase II Release 1 Award	Will demonstrate low-cost stationary energy storage applications by improving the components of regenerative fuel cell systems.
	Lewis Center	Nexceris LLC	\$0.15 million	FY16 SBIR EERE Phase I Release 2 Award	Will develop superior catalysts to convert still gases (methane and ethane) to hydrogen, which can be used for deep desulfurization for ultra-low-sulfur diesel and gasoline in refineries.
OREGON	Corvallis	Oregon State University	\$1.5 million	DOE FCTO Funding Award	Novel hybrid microbial electrochemical system for efficient hydrogen generation from biomass.

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
PENNSYLVANIA	Lancaster	Advanced Cooling Technologies	\$1 million	FY16 SBIR EERE Phase II Release 2 Award	Will develop and demonstrate an efficient non-catalytic plasma-based fuel reformer for converting inexpensive natural gas to hydrogen-rich syngas. Partners include Drexel Plasma Institute, Air Products and Chemicals, Inc. Gas Technology Institute and FuelCell Energy.
	Pittsburgh	National Energy Technology Laboratory (NETL)	\$0.25 million	TCF Award	Cooperative development of NETL electrode engineering process for SOFC commercialization. Joint project with Acumentrics of Westwood, Massachusetts.
	University Park	Pennsylvania State University	N/a	HyMARC	To investigate the synthesis of high-surface area boron-doped polymeric sorbent materials for hydrogen storage, with improved performance for onboard hydrogen storage.
SOUTH CAROLINA	Aiken	Greenway Energy, LLC	N/a	DOE Funding Opportunity Award	To overcome the reliability issues of mechanical compression and the efficiency challenges of solid state compression technologies, this project combines two novel technologies, Electrochemical Hydrogen Compression (EHC) and Metal Hydride Compression (MHC), into a new hybrid solid state hydrogen compressor.
TENNESSEE	Nashville	Vanderbilt University	N/a	FC-PAD	Testing a new technique to electrospin low-platinum group metal electrocatalysts with a proton-conducting binder to improve durability and performance of fuel cell electrodes.
TEXAS	Austin	Nanohmics, Inc.	\$0.15 million	FY16 SBIR EERE Phase I Release 2 Award	A new class of magnetic refrigerants will improve our national hydrogen storage infrastructure and lead to a clean, non-ozone-depleting refrigerant for commercial applications.

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
UTAH	Salt Lake City	Ceratec Inc.	N/a	DOE Funding Opportunity Award	Will improve the performance of durable materials for high temperature water splitting stack technology through the development of a novel cell architecture that introduces macro-features to provide mechanical support of a thin electrolyte, and micro-features of the electrodes to lower polarization losses.
VIRGINIA	Arlington	Strategic Analysis, Inc.	Part of a \$4.75 million award for fuel cell projects (<i>two awardees</i>)	Climate Action Champion Program	Will analyze the cost competitiveness for a range of hydrogen and fuel cell technologies, including those used in hydrogen infrastructure relevant to San Francisco and other projects.
	Pembroke	NanoSonic, Inc.	\$0.15 million	FY16 SBIR BES Phase I Release 1 Award	Will develop and demonstrate high-temperature, hydrocarbon-based membranes that meet the chemical, thermal, and mechanical properties necessary to qualify for the demanding environments that exist within a fuel cell vehicle's lifetime.
	Reston	Vencore Services and Solutions	N/a	DOE Funding Opportunity Award	Will apply integrated cryogenic tank approaches and novel technologies developed by NASA's Cryogenics Test Laboratory to build an integrated subscale insulation system prototype demonstrating the heat leak targets applicable to cryogenic hydrogen storage tanks for commercially produced fuel cell powered automobiles
WASHINGTON	Richland	Pacific Northwest National Laboratory (PNNL)	\$0.17 million	TCF Award	Glass seals with low or zero boria content for high temperature SOFC applications. Joint project with LG Fuel Cell Systems, Inc. of North Canton, Ohio.

STATE	CITY	RECIPIENT	AMOUNT	PROGRAM	PROJECT
DEPARTMENT OF DEFENSE (DOD)					
COLORADO	Lafayette	API Engineering LLC	\$0.72 million	FY16 DOD/Navy SBIR Phase II	The proposed research deals with production of oxygen for use by air independent SOFCs in unmanned undersea vehicles (UUVs).
DEPARTMENT OF TRANSPORTATION / FEDERAL TRANSIT ADMINISTRATION (FTA)					
OHIO	Canton	Stark Area Regional Transit Agency	\$4 million	FTA Low or No Emission Vehicle Deployment Program	Funding toward three zero-emission American Fuel Cell Buses to add to SARTA's planned fleet.
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)					
CONNECTICUT	North Haven	Precision Combustion	\$0.75 million	FY16 NASA SBIR Phase II	Proposes to develop and demonstrate an innovative high power density design for direct internal reforming of regolith off-gases (e.g., methane and high hydrocarbons) within a SOFC stack.
	Windsor	Infinity Fuel Cell and Hydrogen	\$0.12 million	FY16 NASA SBIR Phase I	High Efficiency Advanced Lightweight Fuel Cell (HEAL-FC) - Improvements are planned to make the fuel cell stack more amenable to Unmanned Aerial Systems (UAS) by reducing mass and volume.
OHIO	Lewis Center	Nexceris, LLC	\$0.12 million	FY16 NASA SBIR Phase I Award	Will establish a process model for an externally reformed SOFC system that operates with oxygen and methane reactants, design a reformer and a stack for the system, refine the reformer and stack designs via modeling and analysis, validate the design and performance predictions via catalyst and stack testing.
NATIONAL SCIENCE FOUNDATION (NSF)					
CONNECTICUT	Wallingford	Proton OnSite	\$0.7 million	FY16 NSF SBIR Phase II	Hydrogen bromine electrolysis for highly efficient hydrogen-based energy storage and high value chemical applications.
NEW YORK	Willseyville	Ecoelectro, Inc.	\$1.5 million	FY16 NSF SBIR Phase II	PEM synthesis to enable low cost, durable fuel cells through novel material innovation.

Appendix 3: Endnotes

1. In June 2016, the CVRP exhausted its funding and ZEV applications (for FCVs, BEVs, PHEVs, and zero-emission motorcycles) are wait-listed.
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34. <http://energy.gov/technologytransitions/articles/doe-announces-16-million-54-projects-help-commercialize-promising>
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36. The prototype AFCB was developed as part of the FTA National Fuel Cell Bus Program. Through the non-profit consortia CALSTART, a team led by SunLine Transit Agency and BAE Systems developed the AFCB, a 40-foot EIDorado National bus with a hybrid electric propulsion system by BAE Systems and a fuel cell from Ballard Power Systems.
37. A RPS, also known as a Renewable Electricity Standard (RES), is a voluntary or mandated goal to increase energy production from renewable sources, or from other alternatives to fossil fuels.
38. New York's RPS Main Tier resources are comprised of medium to large scale electric generation facilities that deliver electricity output directly to the wholesale market administered by NYISO.
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