FCHEA
Fuel Cell & Hydrogen Energy Association

Harnessing American Power: Fuel Cell Impact Enabled by R&D

A SNAPSHOT OF FUEL CELLS IN MUNICIPAL APPLICATIONS

About This Report

The report provides an overview of municipal fuel cell applications and recent public-sector fuel cell installations in the United States (U.S.) as of December 31, 2017. Based on the success of early stage research and development (R&D) activities under U.S. Department of Energy (DOE) programs, including those at national laboratories, monitoring public and private fuel cell installations can provide valuable feedback to guide further R&D activities. Over the past few decades, hundreds of thousands of fuel cells have been installed around the world, for primary or backup power, as well as in various other applications including portable and emergency backup power. Fuel cells have also been deployed in other applications such as heat and electricity for homes and apartments, material handling, passenger vehicles, buses, and remote, off-grid sites. This list and contents of report is by no means exhaustive.

Authors and Acknowledgements

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Cover Photo Credits

Top

Left: Plug Power fuel cell forklift at USPS in Capitol Heights, Maryland, courtesy of Fuel Cell and Hydrogen Energy Association

Right: Fuel cell installed at CT Transit in Hartford, Connecticut, courtesy of Doosan Fuel Cell America

Middle

Fuel cell bus at MBTA and hydrogen refueler, courtesy of Nuvera Fuel Cells

Bottom

Left: Fuel cell installed traffic signal in Folsom, California, courtesy of Altergy Systems

Right: Fuel cell tri-generation system, courtesy of FuelCell Energy

Acronyms

ADG	Anaerobic digester gas
CARB	California Air Resources Board
CHP	Combined heat and power
CO_2	Carbon dioxide
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FCV	Fuel cell vehicle
FTA	Federal Transit Administration
kW	Kilowatt
MHE	Material handling equipment
MW	Megawatt
OEM	Original Equipment Manufacturers
PPA	Power Purchase Agreement
R&D	Research and development
SGIP	Self-Generation Incentive Program
WWTP	Wastewater treatment plant

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Fuel Cells: Power for Communities

Fuel cells are becoming an integral part of the workforce – providing reliable, efficient power to facilities and equipment while saving companies money on fuel, labor, and other costs. They are also increasing the country's energy resiliency and security while reducing emissions and the overall environmental impact of everyday operations. Commercial fuel cells are used today in a wide range of market sectors, with tens of thousands now deployed or operating in the U.S. in stationary and motive applications. These fuel cells range in power from kilowatts to multi-megawatts with a growing list of customers that includes top global companies and small homegrown businesses.

In the public sector, fuel cells are also powering government buildings, municipal operations, communications networks and more. Local governments use fuel cells to run city halls, jails, public buildings, wastewater treatment plants and transit buses, and are currently testing fuel cells at airports and ports.

Cities and state agencies are starting to configure fuel cells into microgrids to ensure reliable, efficient power to citizens, as well as to critical outlets such as fire, police and emergency medical services (EMS) in the case of weather-related or other unexpected outages.

Fuel cells generate energy through an electrochemical reaction between hydrogen and oxygen, a process that is inherently clean and efficient.

Fuel cells are in operation at:

- Government and Office buildings
- Wastewater treatment plants
- Communications networks and cell towers
- Railroad and Traffic signals
- Transit Agencies
- Hospitals
- Data centers
- Retail sites
- Grocery stores
- Universities
- Warehouses and distribution centers

Fuel cell demonstrations are taking place at:

- Ports
- Airports
- Harbors (ferries)

There are many reasons why customers in both the public and private sector are choosing fuel cells for stationary and material handling/logistics applications. Examples of economic savings and environmental benefits are outlined in this report, as well as

discussed at length in previous editions, demonstrating that this technology can be an attractive and smart option for customers in a range of markets. Research and development (R&D) and deployment projects are underway to achieve additional improvements and help expand into new areas and make a business case for more commercial applications.

Stationary and Backup Power

Fuel cells are extremely reliable and operate continuously as long as fuel is supplied. Companies involved in keeping the world connected via telecommunications, banking, data transfer, etc. are increasingly turning to fuel cells to seamlessly power daily operations and networks. This includes some of the world's largest technology companies such as Apple, Google, IBM, Verizon, AT&T, Yahoo! and many more.

Fuel cells are also fuel flexible - while most types require hydrogen to generate power, this hydrogen can be sourced from a variety of feedstocks. When using pure hydrogen as the fuel source, besides electricity, the only byproducts a fuel cell generates are water and useful heat. There are no harmful emissions. When using natural gas as the feedstock, the emissions are still much lower than conventional power generation technologies. In California, the Air Resources Board (CARB) factored in the technology's extremely low emissions in permitting requirements and other certifications. Fuel cell products from several manufacturers received Distributed Generation Exemption Executive Orders[i] certifying that the fuel cell systems meet the state's 2007 Fossil Fuel Emission Standards. This helps make siting an installation much easier.

Similar to other industries, many fuel cell customers are entering into power purchase agreements (PPA), which are long-term (usually 20 years) contracts to buy energy at a fixed price. For a detailed explanation of PPAs, see p. 16 of the 2013 edition of this report.

Another benefit of fuel cells is high efficiencies, which are made even greater (~90%) when the excess heat is captured for heating (often called combined heat and power [CHP] or cogeneration), or for cooling and refrigeration.

Table 1. Fuel Cell Benefits – Stationary and Backup Power

	On-Site Power Generation	
	Large Stationary Power: *Buildings, Data Centers, Utilities*	**Small Stationary Power:** *Telecom Towers, Traffic Signals, Off-Grid Equipment*
Savings	Fuel costs Low water usage	Capital and operational savings
Reliability / Efficiency	High reliability – 99.9999% Meets stringent availability standards for data centers Continuous power production when grid goes down High-grade power without voltage sags or surges Byproduct heat can be recovered for use – hot water, facility heating, even cooling	High reliability Maintains performance in extreme hot or cold temperatures Longer runtimes than batteries, generators Reduced reporting and spill mitigation requirements
Low-to-Zero Emissions	Exceptionally low using natural gas, zero-emissions using biogas, hydrogen Exempt from air permitting requirements in California, other states	Zero-emissions
Scalable	Meets any need – can be scaled from kilowatts (kW) to multi-megawatts (MW) Can supply power to electrical grids (largest installation to date is 59 MW)	Can be scaled in size to any application
Compactness / Easy Siting	Small footprint Can be sited on roofs, in basements, indoors, outside Quiet operation	Compact footprint Can be sited on roofs, rugged terrain Quiet operation
Fuel Flexibility	Natural gas, biogas, hydrogen, gasified biomass	Hydrogen, methanol, natural gas

In the public sector, at the federal level, the U.S. Department of Defense (DOD) has been a long-standing fuel cell proponent and early adopter, rigorously testing the technology at military bases and facilities around the country in the late 1990s and early 2000s. These demonstration projects were instrumental in the technology's durability and reliability improvements, and provided invaluable and important experience in siting, operations and maintenance. More recently, DOD's National Security Administration (NSA) has been relying on fuel cells to keep critical operations running at its Fort Meade, Maryland, campus for the several years now, with a 1.6 megawatt (MW) Bloom Energy fuel cell system it installed in 2014.

Locally, fuel cells have been powering government buildings in several states for years, including both New York and Connecticut's City Halls. In California, Sonoma County is powering the twelve buildings of its County Administration Center with 1.4 MW of FuelCell Energy fuel cells while Santa Clara County has a cumulative 2.6 MW of Bloom Energy fuel cells at four different sites, including the Government Center and a correctional facility. The fuel cells are helping both counties reduce carbon emissions by millions of pounds per year while also saving millions on electricity costs.

Microgrids

Severe weather events such as hurricanes, snow storms, extreme heat and droughts have caused significant damage to infrastructure and prevented the delivery of critical services to citizens. Separately, more and more people are moving away from traditional ways to communicate, conduct business, and even pay for goods and services by relying heavily on wireless services and networks. Every second that the electric grid is down doesn't only hit businesses hard but affects consumers across the country at all levels.

To help prevent outages and to alleviate the growing strain on the electric grid, federal, state, and local governments and agencies are looking to microgrids as a way to decentralize power generation, increase reliability and ensure continuous service.

The U.S. Department of Energy (DOE) defines microgrids as "localized grids that can disconnect from the traditional grid to operate autonomously and help mitigate grid disturbances to strengthen grid resilience."[ii]

DOE highlights that "because they are able to operate while the main grid is down, microgrids can strengthen grid resilience and help mitigate grid disturbances as well as function as a grid resource for faster system response and recovery."[iii]

In 2012, after being hit hard by weather-related power outages, Connecticut was first in the U.S. to launch a statewide community microgrid grant program. The program, managed by the state's Department of Energy and Environmental Protection (DEEP), provides grants to municipalities to support critical facilities, which are defined as "any hospital, police station, fire station, water treatment plant, sewage treatment plant, public shelter or correctional facility, any commercial area of a municipality, [or] municipal center."[iv] Connecticut includes fuel cells in its list of eligible Class 1 renewable energy technologies, and the technology is gaining notice as a resilient and sustainable option and proving they should be part of the microgrid mix. Since Connecticut's program launched, other states have added microgrid-specific programs.

A fuel cell can run continuously 24 hours a day, seven days a week, 365 days a year, with 99.9999% reliability. They can be installed as part of the electric grid, or operate in parallel to it. Since many large-scale fuel cell systems can utilize natural gas directly, they are relying on the widespread underground, protected infrastructure of natural gas pipelines in the U.S.

In addition to the fuel cell microgrids at university campuses outlined in Table 2 below, schools and public universities are also using fuel cells, and in many cases, having the technology onsite has led to being designated as an emergency shelter for the town. Several high schools in Connecticut operate Doosan Fuel Cell America systems, while multiple California universities have deployed either Bloom Energy or FuelCell Energy systems on campus. In total, more than 15 MW of fuel cell power has been deployed, or is soon planned for installation, at learning institutions across the country.

Table 2. Recent Fuel Cell Installations – Microgrids

Location	Configuration	Details
Bridgeport, Connecticut	Fuel cell only –1.4 MW FuelCell Energy SureSource power plant	The University of Bridgeport fuel cell generates 80% of power needs for dining hall, recreation and student centers, two residential buildings (as emergency shelter) and police station. Excess heat is captured and used for water heating, then supplied to three campus locations. Microgrid Grant Program - Round 2 Savings of $300,000 per year
Brooklyn, New York	400 kW Bloom Energy fuel cell, 480 kW solar PV, and 300 kW lithium battery for storage	Marcus Garvey Apartment Complex microgrid added as part of a major renovation and revitalization project. Financed from public and private sources, including New York State Homes and Community Renewal and NYSERDA programs. Won 2017 Energy Storage North America Innovation Award for Distributed Storage.
Hartford, Connecticut	Fuel cell only - 800 kW Bloom Energy fuel cell	Fuel cell generates 100% of the electricity for City of Hartford's elementary school, public library, senior center and health center. In case of a grid outage, system is configured to generate emergency power to all those locations, as well as a gas station and grocery store. Excess power produced by the microgrid is also helping reduce costs at three local high schools and a private school. DEEP's Microgrid Grant Program The project is part of the state's Low-Emission Renewable Energy Credits Program, 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.
San Diego, California	2.8 MW FuelCell Energy SureSource fuel cell, 3 MW rooftop solar, 30 MW Combined Cycle Gas Turbine	University of California, San Diego operates a fuel cell-solar-cogeneration microgrid. The fuel cell generates 8% of campus energy needs and utilizes the waste heat in an absorption chiller for cooling. Point Loma WWTP provides the purified methane for the fuel cell, which is injected into an existing gas pipeline to supply the campus fuel cell and two other San Diego fuel cell sites.
Woodbridge, Connecticut	Fuel cell only – 2.2 MW FuelCell Energy SureSource power plant	Fuel cell microgrid provides heat to Amity High School and power to electric grid with an annual estimated savings of $100,000. When needed, switches to microgrid-mode to supply power to 7 critical facilities - high school, town hall, library, fire station, public works facility and senior center/emergency facility. CT DEEP Microgrid Pilot Round Award winner

Figure 1. Bloom Energy fuel cell microgrid in Hartford, Connecticut (L). Microgrid with FuelCell Energy fuel cell at UCSD (R)

Wastewater Treatment Plants

Many large stationary fuel cells today operate using natural gas, but biogas is becoming another popular fuel source. Biogas can be produced in anaerobic digesters (anaerobic digester gas, or ADG) at wastewater treatment plants (WWTP) and then used in the fuel cell to provide electricity and heat for the facility. As the gas is generated from organic waste, many states qualify ADG as a renewable fuel.

For decades, fuel cells have proven themselves at landfills and WWTPs, with demonstrations going back to the 1990s in New York, Connecticut, Oregon, and Massachusetts, as well as China. Fuel cell systems have since been installed at food/beverage processing facilities, breweries (also tested in the 1990s in Japan), and wineries, all using ADG produced from daily operations at the facility.

Today, there are a number of municipal WWTPs in California and Connecticut with fuel cells using ADG produced onsite, helping reduce emissions and eliminate waste. In 2017 alone, three WWTPs in Connecticut, in Fairfield, Naugatuck, and Waterbury respectively, installed fuel cell systems from Doosan Fuel Cell America. A WWTP in West Haven is slated to install one in 2018.

In California, supportive policies and ambitious goals have led to the installation of fuel cells at WWTPs in the state. There are FuelCell Energy fuel cells operating at facilities in Moreno Valley, Perris, the Inland Empire, Orange County, Point Loma (San Diego), Riverside, San Jose/Santa Clara, South Bay, and Tulare, totaling more than 11 MWs.

The California Public Utilities Commission's (CPUC) Self-Generation Incentive Program (SGIP) has been crucial for many of these deployments, providing financial incentives for the installation of power generation technologies that lower emissions and reduce strain on the grid. Fuel cells utilizing biogas have long been favored and now generation projects using natural gas are required to use a minimum of 10% biogas to receive an SGIP incentive, increasing every year until reaching 100% in 2020. The SGIP program is set to receive $83 million annually through 2019.[v]

As mentioned earlier, several fuel cell products are granted exemptions for air quality permitting due to the low emissions. CARB also offered this exemption to FuelCell Energy under the state's 2013 Waste Gas Standards for its product line that utilizes biogas, an added incentive to WWTPs to consider the technology.[vi]

California also has the Bioenergy Feed-in Tariff Program or the Bioenergy Market Adjusting Tariff (BioMAT) for bioenergy renewable generators less than 3 MW in size that offers fixed-price standard contracts to export electricity to the state's investor owned utilities.[vii] Electricity generated as part of this program counts toward the utilities' Renewable Portfolio Standard targets. Biogas produced from wastewater treatment, municipal organic waste diversion, food processing, and co-digestion qualifies under Category 1 of the program.

In 2011, a DOE-funded demonstration project, with support from CARB and the Orange County Sanitation District, showcased the world's first 'tri-generation' plant at a WWTP in Fountain Valley, California. The fuel cell from FuelCell Energy utilized the biogas at the WWTP to generate electricity and heat, and also generated a stream of hydrogen that was used in fuel cell vehicles.

The success of this demonstration project helped pave the way for CARB in January 2017 to grant contingent certification to FuelCell Energy under its Low Carbon Fuel Standard (LCFS) for renewable hydrogen generation using fuel cells at WWTPs.[viii] Each kilogram of renewable hydrogen supplied for vehicle fueling is eligible for a LCFS credit that can be sold or traded to offset carbon-intensive petroleum fuel usage. Final certification is expected following a specified period of operation and review of performance data of a megawatt-class tri-generation system utilizing renewable biogas as the fuel source.

Table 3. Recent Fuel Cell Installations – Wastewater Treatment Plants

Location	Details
Fairfield, Connecticut	In 2017, the Fairfield WWTP installed a 460 kW Doosan Fuel Cell America fuel cell in 2017 to replace a 200 kW fuel cell system that operated from 2005-2010.
Naugatuck, Connecticut	In June 2017, the Naugatuck WWTP installed three 460 kW Doosan Fuel Cell America fuel cells under a 20-year PPA. The fuel cells will provide 85% of the facility's electricity needs and reduce carbon dioxide emissions by more than 3 million pounds per year.
Riverside, California	The Riverside Regional Water Quality Control Plant installed a 1.4 MW FuelCell Energy system to produce about 40% of the total electrical demand at the site, and the storage of excess fuel will reduce the city's need to buy natural gas. The facility can process approximately 40 million gallons of wastewater per day with around-the-clock operations. The continuous power profile of the fuel cells supports the treatment process, utilizing approximately two-thirds of the biogas generated to provide about one third of the power needs for the facility.
Tulare, California	The Tulare WWTP was one of the first to install fuel cells, deploying 900 kW of FuelCell Energy fuel cells (three 300 kW units) in 2007 and adding a fourth one in 2011. The 1.2 MW system provided 45% of the plant's power needs and helped the City of Tulare reduce its electricity bills by more than $1 million a year.[ix] The WWTP is currently in the process of replacing that system with two 2.8 MW FuelCell Energy SureSource 3000 units. The first, fueled by natural gas, was installed under a PPA directly with the City of Tulare. The second 2.8 MW system will be fueled by biogas, which FuelCell Energy will purchase from the City of Tulare under a digester gas purchase agreement. That fuel cell is estimated to be in operation by the end of this year and will export power to the Southern California Edison (SCE) grid under a 20-year PPA executed with SCE under its BioMAT program.
Waterbury, Connecticut	The Waterbury WWTP installed three 460 kW Doosan Fuel Cell America units in 2017. The fuel cells will reduce carbon dioxide emissions by more than 3 million pounds per year and are estimated to save the WWTP approximately $4 million dollars throughout the length of the contract.
West Haven, Connecticut	The West Haven WWTP has plans to integrate a 460 kW Doosan Fuel Cell America fuel cell in 2018.

Figure 2. Doosan Fuel Cell America fuel cell at Naugatuck WWTP in Connecticut (L). FuelCell Energy fuel cell at Riverside WWTP in California (C). FuelCell Energy fuel cell at Tulare WWTP in California (R)

Utilities

Utility companies are also integrating large-scale fuel cell systems, in some cases up to tens of MWs in size, into their portfolios. These utilities are involved in a range of projects involving fuel cell systems, including microgrid and WWTP installations outlined above, as well as deploying fuel cells at existing utility substations to save on the cost of transmission and distribution lines or for use in stabilizing intermittent renewable power sources.

Eversource, Southern California Gas, Dominion, Southern Company, Delmarva Power, Sempra Energy, NRG Energy, Exelon, San Diego Gas & Electric and Avangrid are all currently involved in one or more deployment projects with fuel cell systems in several states. Aside from large-scale installations, these also include partnerships to sell fuel cell products to customers and incorporating fuel cells for backup power into communications networks. The 2016 edition of this report (pages 55-57) provides an overview of recent utility projects and partnerships with fuel cell manufacturers.

Of note in 2017, two big utility-led projects were announced in the Northeast U.S., both involving FuelCell Energy.

The Connecticut Municipal Electric Energy Cooperative (CMEEC), which consists of six municipal utilities (Groton Utilities, Norwich Public Utilities, Jewett City Department of Public Utilities, Bozrah Light and Power, South Norwalk Electric and Water and Norwalk Third Taxing District), will deploy 7.4 MW of FuelCell Energy fuel cells at the U.S. Navy Submarine Base in Groton.[x]

In New York, FuelCell Energy will be installing a total of 39.8 MW of fuel cells at several Long Island Power Authority (LIPA) electrical substations. The installations are funded via a 20-year PPA as part of PSEG Long Island's Clean Renewable Energy Feed-In Tariff II program, which works to enhance energy resiliency.

Announced sites include[xi]:

- 18.5 MW near the Brookhaven Rail Terminal in Yaphank;
- A separate 7.4 MW installation in Yaphank; and
- A 13.9 MW combined heat and power project in the town of Brookhaven.

Backup Power Systems

As of the end of 2017, there were currently more than 8,500 fuel cell systems[xii] installed or on order across the United States at a variety of sites for backup power. While the majority are for private sector companies in the telecommunications and rail industries, an increasing number are being utilized by federal and state government facilities and utility networks. This includes agencies such as the Federal Aviation Administration which, with DOE, deployed a fleet of Plug Power fuel cells to provide backup power to radio transmit receivers (TRT), air traffic control sites, and first responder networks in cities around the country.

In late 2017, the Alexandria, Virginia, Department of Transportation and Environmental Services installed an Altergy Systems' fuel cell at a busy intersection as a backup power source for traffic signals.[xiii] The fuel cell can provide up to eight hours of power to keep the signals operating in the case of a power outage.

Transportation

Federal, city and local government fleet vehicles such as cars, buses, material handling and other utility vehicles are a prime target for the deployment and testing of fuel cells in these transportation applications. The appeal of these fleet vehicles as a platform for fuel cells is the central fueling, maintenance and storage facilities. A key challenge, as with other advanced technologies, is cost and more R&D is underway to reduce component and material costs. However, these systems are well beyond the laboratory phase and commercial deployments are helping to create economies of scale and enable

infrastructure, a domestic supply chain and user acceptance. Examples of benefits are shown below.

Table 4. Fuel Cell Benefits – Transportation

	Material Handling *Forklifts, Ground Support Equipment*	**Fleet Vehicles** *Cars, Vans, Buses, Trucks*
Cost Savings	Lower operational costs compared to batteries Reclaim warehouse space used for battery storage and/or charging	Free fuel for 3 years (Hyundai, Honda) $15,000 of free fuel (Toyota)
Reliability / Efficiency	High reliability Maintains performance in cold/refrigerated environments Increased productivity Can operate a full eight-hour shift before refueling Refuel in 1-2 minutes	Highly reliability Performs well in all climate conditions, from extreme heat to extreme cold Range of 300+ miles per fueling Refueling takes 3-5 minutes for cars, less than 10 minutes for buses
Low-to-Zero Emissions	Zero Emissions	Zero Emissions
Scalable	Can scale to power entire forklift fleets with minimal increase in fueling infrastructure depending on fleet size	Can scale fuel cell power output to supply power for a range of vehicles – cars, vans, buses, Class-8 and other trucks
Fuel Flexibility	Hydrogen sourced from natural gas and/or renewables Hydrogen can be generated on-site or delivered Methanol is another fuel source in this application	Hydrogen sourced from natural gas and/or renewables Can be generated on-site or delivered

Material Handling

There are more than 20,000 fuel cell-powered forklifts[xiv] in operation at warehouses and distribution centers in more than 25 U.S. states and several countries around the world. This number includes deployments at facilities owned by Fortune 500 corporations as well as small businesses. Much of this market sector's success can be attributed to DOE's early support of fuel cell material handling equipment (MHE) demonstrations in both the private and public sector in 2009. One of the government agencies that helped lead that charge was DOD's Defense Logistics Agency (DLA), in collaboration with DOE's FCTO over a decade ago. Through pilot projects in several distribution depots and warehouses, DLA gathered invaluable experience and data that led to technical advancements and regulatory progress, such as codes and standards for indoor hydrogen dispensing. Data collected by DOE's National Renewable Energy Laboratory helped to guide further early stage R&D to help drive down cost and improve performance in the past several years.

In 2017, a major public sector agency joined the long list of fuel cell forklift customers. The U.S. Postal Service placed 80+ fuel cell MHE vehicles at its National Distribution Center in Capitol Heights, Maryland. The fuel cells for the equipment were from Plug Power and two hydrogen dispensers were installed by Nuvera.

Fuel Cell Cars

Fuel cell vehicles (FCVs) from three major automakers are already available to customers in California, and there are now more than 4,800 on the road there. City and local governments in the state are also beginning to incorporate FCVs into their fleets and motor pools. This includes the City of Long Beach and Sacramento County, both of which added Toyota Mirai FCVs to their fleets.[xv]

Fuel Cell Transit Buses

Fuel cells are also providing reliable zero-emission transportation to the public across cities, metropolitan regions, and even state universities.

Fuel cell bus deployment gradually expanded in 2017, with fuel cell buses currently or soon to be found in at least seven states across the country. Transit agencies are placing fuel cell buses in revenue service to help curb emissions and demonstrate the viability of the technology in fleets. Each fuel cell bus deployed can help save more than 9,000 gallons of fuel, or $37,000 a year when replacing diesel buses, not to mention reducing carbon emissions by 100 tons a year, according to the California Fuel Cell Partnership.[xvi]

California, home to most of the country's fuel cell cars, also has the largest number of fuel cell buses. Three public transit agencies operate at least 20 fuel cell buses in the Coachella Valley, Downtown Riverside, the eastern region of the San Francisco Bay Area, and Orange County. The University of California-Irvine also operates a fuel cell bus to transport students locally. More than 33 additional fuel cell buses are currently in development for operation across the state.

Thanks to support from the Federal Transit Administration (FTA), fuel cell buses are being adopted by transit agencies even in states without robust hydrogen infrastructure. The most prominent case of this is in Ohio, where the Stark Area Regional Transit Authority (SARTA) currently operates a fleet of seven fuel cell buses. One fuel cell bus is on loan to the Ohio State University, and transports students across campus as part of a collaborative study. A September 2017 grant for $1.75 million from the FTA's Low or No-Emission Bus Program will allow SARTA to purchase two new buses to continue its fleet expansion. SARTA expects to operate a fleet of at least thirteen fuel cell buses by the fall of 2018. In addition, a July 2017 SARTA report[xvii] outlines plans to install hydrogen stations in major Ohio cities over the next few years to support further fuel cell bus deployment.

The Massachusetts Bay Transportation Authority (MBTA) now operates a fuel cell bus for public transit in Boston. Massachusetts-based Nuvera Fuel Cells coordinated the program and provided the hydrogen station, BAE Systems and ElDorado National provided the bus with a Ballard fuel cell, and the FTA's National Fuel Cell Bus Program provided funding for the deployment.

In Michigan, the Flint Mass Transportation Authority operated a fuel cell bus on different city routes in 2017 through a National Fuel Cell Bus Program demonstration project and feasibility study. And in Delaware, the FTA continues to fund a decades-

long fuel cell bus program at the University of Delaware. In addition to transporting students around campus, these buses have been very successful in training students and engineers interested in fuel cell technology.

Looking ahead, the FTA's Low or No-Emission Bus Program recently provided a $1.45 million grant to the Champaign-Urbana, Illinois Mass Transit District (MTD) for the purchase of two fuel cell buses and associated hydrogen infrastructure. The grant will make MTD the first transit authority in the state to add fuel cell buses to its fleet. In addition, the Hawaii Department of Transportation plans to operate a fleet of eight fuel cell shuttle buses at Honolulu International Airport later in 2018. The project is part of an effort to facilitate early heavy users of hydrogen, starting with public fleets, in order to develop a hydrogen market in the state.

Port Logistics: Class 8 Heavy – Duty Trucks

Ports have a large impact on the surrounding environment, with pollution coming from not only the cargo ships, but the vehicles moving and transporting the goods once they arrive. Fuel cells can help ports meet federal and local restrictions on emissions, with the added benefit of quiet operation.

Two of the biggest ports in the U.S., the Ports of Los Angeles and Long Beach, are helping pave the transition to completely zero-emissions class 8 heavy duty trucks for drayage operations. Several field demonstrations are currently underway to determine the feasibility of fuel cell-powered trucks in port operations.

With funding from DOE and the South Coast Air Quality Management District, the San Pedro Bay Ports Zero Emission Cargo Transportation project (ZECT) brought together three teams of Original Equipment Manufacturers (OEMs) and vehicle integrators to demonstrate fuel cell-powered drayage trucks. Companies involved include fuel cell manufacturers, trucking companies and

Figure 3. Toyota Fuel Cell Truck

integrators, including Hydrogenics, Ballard Power Systems, TransPower, US Hybrid, and Kenworth Truck Company.

Separately from the team demonstrations, Toyota unveiled its Project Portal fuel cell truck concept in April of 2017. Under normal drayage operations, Project Portal can travel an estimated 200 miles per fill of hydrogen with a gross combined weight capacity of 80,000 lbs. Project Portal began its feasibility study in October 2017, and is currently performing daily drayage operations at the San Pedro Bay Ports.

Seeing an opportunity to fuel these vehicles renewably, Toyota announced it is working with FuelCell Energy to construct a multi-megawatt fuel cell power plant at the Port of Long Beach to generate 100% renewable hydrogen fuel onsite. The power plant will generate hydrogen fuel and stationary power by capturing methane gas from dairy cattle waste. The system is planned for operation by 2020. The facility will be able to supply approximately 2.35 MW of electricity and 1.2 tons of hydrogen per day – the equivalent of about 2,350 average sized houses and nearly 1,500 FCVs.

Powering Forward

In addition to all the municipal installations, demonstrations and deployments outlined in this snapshot report, fuel cells are also making headway in a number of other public sector applications such as airport ground service equipment, garbage trucks, transport ferries and more. This progress, combined with the surge in R&D, innovation, investment, and purchases from the private sector, could help the U.S. lead a worldwide energy revolution here at home - utilizing domestic fuel sources and supporting American manufacturing, supply chain and service companies all while reducing emissions, increasing reliability and ensuring we all stay connected.

Endnotes

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Figure 2 – Left: Courtesy of Veolia North America
Center: Courtesy of FuelCell Energy

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Figure 3 – Courtesy of Toyota