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State of the States: Fuel Cells in America 2014 5th Edition Fuel Cell Technologies Office December 2014

SOUTH CAROLINA

Almost a decade ago, South Carolina identified its strong capabilities in hydrogen and fuel cells technologies and began–through partnerships of government, business and academia – to nurture a growing fuel cell industry in the state.

In 2005, several studies (*SCH2 - The South Carolina Hydrogen Economy: Capitalizing on the State's R&D Assets and South Carolina Hydrogen & Fuel Cell Economy Strategy Final Report*) found that South Carolina has the infrastructure, technology, and resources to be competitive in a hydrogen economy and that it should exploit these capabilities.[46] The state began to implement a cluster strategy that creates a closely knit concentration of producers, sup-pliers and institutions focused on emerging industries that the state expects to grow and achieve competitiveness.[47] The Hydrogen and Fuel Cell Cluster (part of the Future Fuels Cluster) is recognized as one of South Carolina's important economic clusters.

Also in 2005, the South Carolina Hydrogen and Fuel Alliance (SCHFCA) was formed to oversee the state's fuel cell strategy and promote the state's hydrogen and fuel cell cluster. Members include federal and state government offices (Savannah River National Lab, the South Carolina Department of Commerce, Energy Office, Fire Marshal's Office, and Department of Minority Affairs), private companies, coali-tions and partnerships, and university and research facilities in the state. SCHFCA's report, *Economic Development: South Carolina's Hydrogen and Fuel Cell Cluster* (2014), proposes a "Hydrogen and Fuel Cell Cluster Action Plan" for continued growth of the industry in the state. South Carolina

46 http://www.sunycnse.com/download/Anthony_Boccanfuso_New_Energy_Symposium.pdf
47 http://www.schydrogen.org/documents/2005%20Next%20Energy%20Initiative%20study.pdf

Since our last report:

- The University of South Carolina's Solid Oxide Fuel Cell Center was ranked #1 in total funding ($54 million) out of the state's 51 SmartState Centers.The SmartState Program, established in 2002, authorizes South Carolina's three public research institutions (Clemson University, Medical University of South Carolina, and University of South Carolina) to cre-ate Centers of Economic Excellence in research areas that will advance the state's economy.The SmartState Program has attracted more than $1.2 billion in non-state investment and has created more than 7,000 jobs.Funding comes from the state lottery.In June 2014, the University was awarded $3.2 million from the federal ARPA-E program.

- The South Carolina Hydrogen and Fuel Cell Alliance issued a report, *Economic Development: South Carolina's Hydrogen and Fuel Cell Cluster* (Feb.2014), with an Action Plan for continued growth of the industry.

- South Carolina legislature created a Distributed Energy Resource Program to increase distributed energy resources in the state.Energy utilities may choose to participate in the program, which will include resources up to 20 kW for residential and 1 MW for nonresidential DG.Hydrogen from renewable resources is defined as an eligible renewable generation resource under the program.New interconnection and net metering rules will be established

has completed mapping of its fuel cell and hydrogen supply chain, the first in the country to do so using the North American Industry Classification System (NAICS) code.

The ***South Carolina Innovation Plan 2013***, a roadmap to strengthen the development of the state's "innovative econo¬my," also recommends that efforts and resources should focus on advancing growth in high-tech firms in industries that have the most high-growth potential – which includes the fuel cell and hydrogen cluster.

Additionally, the state's General Assembly recently ***amended Section 12-6-3588*** of the 1976 Code to enact the South Carolina Clean Energy Tax Incentive Program, "to encourage business investment that will produce high quality employment opportunities and enhance this state's position as a center for production and use of clean energy prod-ucts. The program accomplishes this goal by providing tax incentives to companies in the solar, wind, geothermal, and other clean energy industries which are expanding or locating in South Carolina."

University of South Carolina and City of Columbia

The ***South Carolina Research Innovation Centers Act of 2005*** directed the ***South Carolina Research Authority (SCRA)*** to create

three "innovation centers" within the state, and specified eleven technology domains, including hydrogen and fuel cell technology, where the state should concentrate its economic development efforts. The ***Industry Partners Act of 2006*** further directed SCRA to stand up a "target program of excellence" in hydrogen and fuel cell technology through collaboration between the University of South Carolina and the Savannah River National Laboratory (SRNL). The comprehensive, state-wide innovation program, called SC Launch, is run by SCRA.

In 2006, the University of South Carolina (USC) and City of Columbia formed the ***Fuel Cell Collaborative***, (along with partners EngenuitySC, Midlands Technical College and the SCRA) to position Columbia and the Midlands region as a leader in hydrogen and fuel cell innovation and tech-nology. In 2006, Columbia's city council unanimously passed a resolution supporting the city's objective to become a leader in fuel cell innovation. The council also created the ***Columbia Fuel Cell District*** in downtown Columbia, which integrates research, educa-tion and outreach, hydrogen production and fueling, and multiple end-use applications. In 2014, SRNL also joined the Fuel Cell Collaborative.

The ***Greater Columbia Fuel Cell Challenge*** was also launched in 2006 to accelerate the commercialization of ideas and discoveries, from discovery and development, to fuel cell demonstrations and deployments. Over its history, the Challenge has funded a wide array of projects including the development and testing of fuel cell prototypes, various demonstrations of fuel cell technologies (e.g. fuel cell forklifts trialed at multiple Columbia-area com-panies, fuel cell backup power units installed at three Columbia radio communications sites and at the Northeast Campus of Midlands Technical College, portable power fuel cell prototypes for multiple manufacturers, "repurpos-ing" a 5-kW fuel cell system for powering the scoreboard at USC's baseball stadium, etc.).

In June 2009, the Fuel Cell Collaborative was selected to receive the "Innovator Award" from the Southern Growth Policies Board. The citation accompanying this award noted the group's "collaborative partnership with the public, private, university, government and nonprofit sectors" as the basis for the award.

In September 2011, the Collaborative received recognition from the International Economic Development Council as a recipient of its "Excellence in Economic Development Award," citing the group's "innovative use of technolo-gies to promote energy efficiency; promotion of cross-industry collaboration; commercialization/technology trans-fer; preparation of workers for green collar jobs; and its replicability to other organizations or geographic areas."

South Carolina is home to two hydrogen fueling stations, located in downtown Columbia and in Aiken. Both were opened in 2009. The two stations are located about 50 miles apart, creating a "SC Hydrogen Freeway" along Interstate 20.

The Columbia station was developed when the FTA's National Fuel Cell Bus Program selected Columbia as a site for a prototype fuel cell bus demonstration. The bus serviced routes for the Central Midlands Regional Transit Authority (CMRTA) and for the USC campus starting in the fall of 2009, before moving to a follow-on

demonstration site (Austin, TX) in 2012. The hydrogen station continues to service a small fleet of FCEVs in the area.

The Aiken Sage Mill Industrial Park hydrogen station, developed by the Aiken-Edgefield Economic Development Partnership (EDP), along with partners DOE, GENCO, Kimberly-Clark Corporation, Plug Power Inc., and Air Products, is the nation's first multi-use industrial park fueling station to supply hydrogen directly for industrial, commercial, and government use.

The EDP, the Applied Research Center (ARC), and the city of North Augusta also partnered to obtain a fuel cell bus, which began operation in the city in 2014. The city, which has been working on ways to become more environmentally friendly, obtained the bus through a competitive process.

USC, located in Columbia, plays a major role in the state's fuel cell and hydrogen cluster. The university is home to the ***Solid Oxide Fuel Cells Center of Excellence***, which has partnered with the Boeing, ExxonMobil, SRNL, DOE, NASA, Department of the Navy, and the Air Force Office of Scientific Research, among others. The SOFC Center has added $31.2 million in research support and more than 270 jobs to South Carolina since 2008. USC also hosted the Center for Fuel Cells (which sunsetted at the end of 2013), a National Science Foundation Industry/ University Cooperative Research Center that worked with industry partners such as BASF, Boeing, Dow Corning, DuPont, FuelCell Energy, GM, LG Electronics, Plug Power, and Proton Onsite.

USC's Center for Electrochemical Engineering (CEE) is also conducting crucial fuel cell research and has received millions in federal dollars from DOE and NSF over the years for research in fuel cell contaminants and electrolyz-ers. Dr. Branko Popov, Director of the CEE, was recognized by Thomson Reuters as one of the most "Highly Cited Researchers 2014" for his work on batteries and fuel cells. Dr. Popov has received DOE funding to develop novel non precious metal catalysts for fuel cells and currently is using funding from DOE and NSF to develop ultra-low loading platinum catalysts for PEM fuel cells. He has also received funding from NASA for the development of advanced regenerative fuel cells.

USC has been involved in many fuel cell demonstrations and deployments. USC's Green Quad dormitory installed a 5-kW fuel cell that powered the lights and hot water for the Center for Sustainability, funded by $100,000 from DOE and $50,000 from the South Carolina Energy Office. The University also leased two Ford hydrogen fuel cell buses, owns two fuel cell-powered Segways, and powers its baseball stadium scoreboard using a fuel cell.

Other Industry/Academia

Midlands Technical College (MTC), located in Columbia, offers fuel cell technology training programs and has devoted two full-scale labs to the design and fabrication of fuel cell technology. The MTC Enterprise Campus also serves as a business accelerator, and is currently home to TruLite, a manufacturer of fuel cell power generators for backup and off-grid applications.

Fuel cell research is also conducted at Clemson University's International Center for Automotive Research.

The Applied Research Center (ARC), located at the Savannah River Research Campus in Aiken, was initially established as a center for hydrogen fuel and fuel cell R&D. The facility has since broadened its research efforts beyond hydrogen, but it still remains one of the facility's primary research initiatives. ARC researchers work in collaboration with SRNL and the facility is home to SRNL's Hydrogen Technology Research Laboratory (HTRL). ARC: Hydrogen projects have included the development of a Chevrolet Silverado 4X4 truck with a hydrogen-pow-ered internal combustion engine and the Sage Mill Industrial Park hydrogen refueling station in Aiken. The ARC initiatives are programs of the Aiken-Edgefield Economic Development Partnership. In addition, ARC: Hydrogen is partnering with SRNL and the AIST (Advanced Institute of Science and Technology) of Japan on renewable hydrogen systems.

Several major corporations with facilities in South Carolina have taken advantage of fuel cell power.

BMW operates 350+ fuel cell-powered forklifts, tuggers and stackers at its Spartanburg manufacturing plant and a 700 kg/day hydrogen fueling pump. The company also has used methane gas-to-power part of the plant's total en-ergy requirements, earning the company the #4 spot on EPA's "Top 20 Onsite Generation" list. The gas is collected

from the local Palmetto landfill and is cleaned, compressed and delivered to the plant via a 9.5-mile pipeline. BMW, the South Carolina Research Authority, the Gas Technology Institute, Ameresco Inc., and the South Carolina Hydrogen and Fuel Cell Alliance are working together to develop a method to convert some of this methane gas onsite into hydrogen for the fuel cell forklifts. This effort is funded, in part, by a grant from DOE.

Kimberly-Clark operates a fuel cell-powered forklift fleet at its Aiken facility. Bridgestone-Firestone (also located in Aiken) also demonstrated fuel cell forklifts at its manufacturing plant for several years, placing them in service in 2008/2009.

Proterra, a manufacturer of electric and fuel cell buses located in Greenville, is working on several projects, and recently demonstrated the driving range of their hydrogen fuel cell bus as part of the Federal Transportation Administration fuel cell bus program. The bus was driven to the Sage Mill Hydrogen Station in Aiken, SC, ap-proximately 109 miles, for refueling. The Sage Mill Hydrogen Station is the only station in a several state area with the 5,000 psi capability needed to fuel the bus.

OVERVIEW OF SOUTH CAROLINA'S FUEL CELL AND HYDROGEN INITIATIVES

PROGRAM	DETAILS
AGENCY: SOUTH CAROLINA RESEARCH AUTHORITY (SCRA)	
SC Research Innovation Centers Act (2005)	Directed SCRA to create three "innovation centers" and specified 11 technology domains, including hydrogen and fuel cell technology, where the state should concentrate its economic development efforts.
Industry Partners Act (2006)	The Act further directed SCRA to establish a "target program of excellence" within each of the three research innovation centers and to focus on the application, development, and commercialization of the basic research being undertaken by the centers. This includes a target program of excellence in hydrogen and fuel cell technology through collaboration between the University of South Carolina and SRNL. An Industry Partnership Fund was established by the Act to carry out the program's objectives. Taxpayers received a state income tax credit (or other form of credit) for voluntary contributions to the fund. The fund sunsetted in mid-2012.
AGENCY: PUBLIC SERVICE COMMISSION (PSC)	
Hydrogen Permitting Act	The bill establishes a South Carolina Hydrogen Permitting Program within the Office of the State Fire Marshal. The bill also states that only the state fire marshal may permit a hydrogen facility in the state and that the fire marshal may delegate that authority to a county or municipal official.

Sales Tax Exemption for Hydrogen Fuel Cells	Exempts from sales tax any device, equipment, or machinery operated by hydrogen or fuel cells, any device, equipment, or machinery used to generate, produce, or distribute hydrogen and designated specifically for hydrogen applications or for fuel cell applications, and any device, equipment, or machinery used predominantly for the manufacturing of, or research and development involving hydrogen or fuel cell technologies.
South Carolina Distributed Energy Resource Program	The goal of the voluntary program is to promote the establishment of a reliable, efficient, and diversified portfolio of distributed energy resources for the state. Any distributed energy resource program proposed by an electrical utility must, at a minimum, result in development by 2021 of renewable energy facilities located in South Carolina in an aggregated amount of installed nameplate generation capacity equal to at least 2% of the previous five-year average of the electrical utility's South Carolina retail peak demand. Eligible facilities must be 20 kW or less (residential customers) or 1 MW or less (nonresidential customers). Hydrogen fuel derived from renewable resources qualifies as a renewable generation source.
Net Metering	The 2014 Distributed Energy Resource Program Act creates new net metering rules. Residential customers can net meter renewable systems of 20 kW or less. Nonresidential customers can net meter systems that are 1 MW or less, or 100% of contract demand. The net metering rules do not permit meter aggregation, group/ joint billing projects, and/or virtual net metering.
Interconnection Guidelines	In 2006, the PSC adopted simplified interconnection guidelines for small renewable energy systems and other forms of DG – up to 20 kW for residential systems and up to 100 kW for non-residential systems. The interconnection guidelines apply to Progress Energy, Duke Energy, and South Carolina Electric and Gas. The 2014 Distributed Energy Resource Program Act directs PSC to promulgate standards for interconnection of renewable energy facilities and other non-utility owned generation with a generation capacity of 2 MW or less to an electrical utility's distribution system.

Hydrogen Cars, Coming Down the Pike

By THE EDITORIAL BOARDNOV. 29, 2014

Inside

The once-distant promise of clean, affordable hydrogen-powered cars is starting to become a reality.

Several major automakers, including Toyota, Honda and Hyundai, have started or will soon start selling these

cars, which will be more expensive than comparable gasoline models but a lot cheaper than they were just a few years ago.

Executives at Toyota say that the cost of making the critical components of hydrogen vehicles has fallen 95 percent since 2008. That is why the company plans to market its first mass-produced hydrogen car, the Mirai, in the United States next year. Other companies, like General Motors, Ford and Audi, are working on similar cars.

The broad adoption of hydrogen-powered cars, which emit only water and heat, could play an important role, along with electric vehicles, in lowering emissions of carbon dioxide and other pollutants responsible for climate change. Cars and other modes of transportation account for about 28 percent of greenhouse gas emissions in the United States, second only to power plants, according to the Environmental Protection Agency.

Instead of an engine that burns gasoline, cars like the Mirai have fuel cells that combine hydrogen with oxygen from the air to generate electricity that powers a motor. The hydrogen is stored in tanks that can be filled in a few minutes, just like a conventional gasoline tank. By comparison, a gasoline-electric hybrid car like the Toyota Prius also uses an electric motor and generates electricity in part by burning gasoline. And all-electric vehicles like the Tesla Model S store power in batteries that are usually charged from the electricity grid.

Most hydrogen today is created from natural gas in a process that generates carbon dioxide. But scientists say fuel cells are still good for the environment, because making hydrogen produces far fewer emissions than burning fossil fuels. Hydrogen could be produced more cleanly by using alternative energy sources like solar and wind power to split water into hydrogen and oxygen atoms. And it can be generated from renewable sources like sewage and animal waste.

Auto companies, universities and government labs have been working for decades to make fuel cells cheaper, more reliable and more efficient. They have come a long way. In the early 2000s, hydrogen concept cars cost automakers as much as a million dollars to make. The Mirai will sell for $57,000. Another car already on the market, the fuel-cell version of the Hyundai Tucson, is available on a $499-a-month lease. Auto executives and fuel-cell researchers say they are confident the price of this technology will fall sharply in coming years, just as the cost of hybrid cars fell in the last decade.

But cost isn't the only problem. There are just 13 hydrogen fueling stations in the United States today, according to the Department of Energy. Big investments will be needed, and some are on the drawing board. The state of California, where many of the first fuel-cell cars will be sold, plans to spend up to $200 million to build 100 fueling stations in a decade. Countries like Japan and Germany are also investing in refueling stations. And car companies like Toyota and Honda are providing loans to help their business partners build hydrogen stations.

The development of fuel-cell technology has been helped along by federal and state government support. The Clinton, Bush and Obama administrations invested in hydrogen research to varying degrees. Government agencies should continue to provide support, especially in creating a network of refueling stations. Eventually, as the number of fuel-cell cars on the road increases, gas stations will themselves invest in hydrogen.

Some critics of hydrogen cars say they remain expensive and impractical compared with electric vehicles, which can be plugged into the existing electricity system. But that is shortsighted. The real competition for hydrogen-powered and electric vehicles is the gas guzzler. There is little doubt that the world will need many transformative technologies to deal with climate change.

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