CleanEnergy States Alliance

STATIONARY FUEL CELLS AND CRITICAL POWER APPLICATIONS

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ABOUT THIS SERIES

This briefing paper is one of four in a series of papers on fuel cells and hydrogen technologies produced by Clean Energy States Alliance (CESA) in the spring of 2010. These papers are part of a larger education and outreach initiative by CESA to inform and engage state policymakers about the benefits of fuel cells, their use in critical power applications, and model state policies to support them as well as information about hydrogen production and storage:

- *Fuel Cell Technology: A Clean, Reliable Source of Stationary Power*
- *Stationary Fuel Cells and Critical Power Applications*
- *Advancing Stationary Fuel Cells through State Policies*
- *Hydrogen Production and Storage: An Overview*

For further information on CESA's hydrogen and fuel cell activities, and to download all four reports, please visit *www.cleanenergystates.org/JointProjects/hydrogen.html*.

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Introduction

In recent years, events ranging from weather to natural disasters to human error have exposed the vulnerability of our electric grid. For many individuals and businesses, these power outages are often no more than a temporary inconvenience. But for critical facilities in both the public and private sector—telecommunications towers, hospitals, airports, emergency dispatch, banks and data centers, and even basic infrastructure such as water and sewage pumps, traffic signals, and refrigeration—even brief outages represent a risk to public safety and potentially significant societal and economic costs.

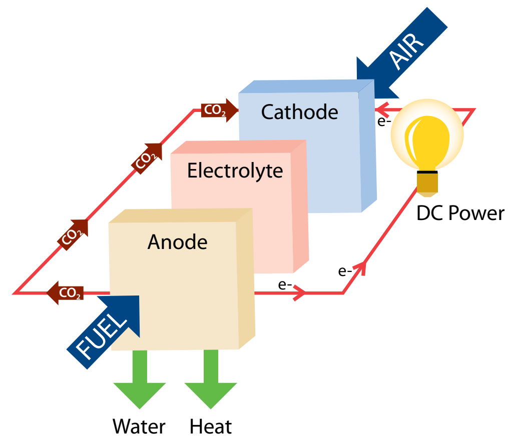
For decades, these types of critical facilities have relied on two types of back-up power: banks of valve-regulated lead-acid (VRLA) batteries and diesel generators. While both of these technologies are relatively low cost, each has shortcomings, particularly for facilities that need to plan for power outages measured in hours and days, not minutes.

VRLA battery systems are typically designed to only provide power for approximately 15 minutes at full power, enough time to complete an orderly shutdown of equipment. They can also assure a constant supply of power so that even temporary (under 1 minute) power outages or surges do not disrupt computer equipment. However, batteries are sensitive to extreme heat and cold, making them imperfect for outdoor applications in many locations, and they need to be replaced every few years due to declining performance.

Diesel generators (gensets) are today's primary source of backup power. However, they are inefficient, produce emissions from fuel combustion, and require periodic maintenance. Often, they are not suitable for urban locations, where the associated noise, fuel storage, and pollution are unwelcome. In some jurisdictions, such as the state of California, the use of diesel generators for back-up power purposes is subject to strict air quality regulations. In addition, in extreme disasters and prolonged power outages, diesel generators are reliant upon the delivery of fuel. Hurricane Katrina and the earthquake in Haiti are both reminders of that risk.

Fuel cells are a technology that both the public and private sectors are increasingly turning to for both primary and back-up power needs. Although the understanding of the chemistry of fuel cells goes back more than a century, they are very much a 21st century technology.

Figure 1:
How a Molten Carbonate Fuel Cell Works



The basic design and electrochemical principle behind fuel cells is straightforward. A fuel cell stack requires only hydrogen (or a similar energy carrier), oxygen, and an electrolytic solution. Hydrogen and ambient air flow into the fuel cell, which contains an anode and a cathode. At the anode, the hydrogen separates into a proton and an electron. The proton migrates to the cathode, where it reacts with the oxygen to form water. The electrons, which cannot pass through the membrane, flow from the cell to provide useful electrical power.

Fuel cells are quiet, have no moving parts, and produce no particulate emissions. They are virtually maintenance-free and can be both tested and operated remotely. Because they are modular, they can be configured for any size power needs, from a few kilowatts for a remote telecommunications tower to megawatt-scale for hospitals and airports. Hydrogen is safely stored on-site or produced within the fuel cell itself. (For more on fuel cell technologies, please see accompanying CESA briefing papers at *www.cleanenergystates.org/JointProjects/hydrogen.html*.)

Fuel Cell Application Platforms

There are two primary application platforms in the use of fuel cells for critical facilities. The first application uses fuel cells strictly as *standby* power in the event of grid failure. The second application utilizes fuel cells as a high-quality source of *primary* power for the facility that will also continue to provide uninterrupted power during an electrical outage.

Standby Power

In a standby power application, the fuel cells, or a combination of fuel cells and batteries, provide direct current (DC) power to run the equipment or facility. The fuel cells have internal batteries that provide temporary "bridge" power until the fuel cell reaches peak power production and takes over the load. When grid power is restored, the fuel cells shut down. Fuel cells can be ramped up quickly and can operate indefinitely as long as there is a continuing source of hydrogen or other fuel. Proton Exchange Membrane (PEM) fuel cells are used for this application.

Primary Power

As a source of primary power, fuel cells can provide consistent, distributed, high-quality power generation to a facility, regardless of disruptions to the electric grid. This model is a significant paradigm shift in thinking about critical power because the fuel cell provides reliable, base-load power generation and continues to operate even when the electric grid goes down. Because they are used continuously and systems can be configured to use by-product heat from the fuel cells, the capital costs of the fuel cells can be spread out over all facility operating hours. Fuel cells can also displace purchases of both electricity and natural gas.

Cost/Benefit

Fuel cells do have higher up-front costs when compared to other forms of both standby and distributed generation. But these costs can be lower on a life-cycle basis because of the reduced replacement and maintenance needs. Further, the higher reliability of fuel cells means that the potential human, social, and economic costs of prolonged power outages can be greatly reduced. Finally, fuel cells owned by private companies are eligible for a 30% federal investment tax credit further lowering the cost differential with other forms of backup power.

Applications of Fuel Cells in Critical Facilities

Telecommunications

The telecommunications industry relies on a network of cell phone towers and field facilities to transmit phone calls and data. To operate effectively, each of these towers and field facilities requires a constant and highly reliable electrical power supply. Currently, the primary source of backup power for communications towers is lead-acid batteries. However, batteries can provide power for only a limited duration. In addition, since many telecommunications towers are located in remote areas, maintaining these battery banks can be challenging. These towers are, therefore, an ideal application for fuel cells. The fuel cell and hydrogen tank can be securely stored behind a fence at the tower and can be operated automatically and remotely.

The State of Pennsylvania is currently installing a hybrid power solution microcell communications site in Clinton County. The site will use solar photovoltaics and a small wind turbine, with a PEM fuel cell manufactured by ReliOn providing backup power when the solar and wind generation are insufficient. The site supports first responder communications activities, making it critical that it be operational at all times.

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Table 1: Relative Comparison of Characteristics of Backup and Distributed Power Systems

Technology	Initial Capital Cost ($/kW)	Variable O&M ($/kWh)	Maintenance Requirements	RunTime	Fuel Emissions	Lifespan
Battery	400–900 (Lead-Acid)	Depends on local electric rates	Low	Short	No direct emissions	Short
Diesel Genset	350–800	0.025	Medium	Long (if fuel available)	Significant	Long
Natural Gas Engine	450–1100	0.025	Medium	Long	Low	Long
Microturbine	950–1,700	0.014	Medium	Long	Low	Long
PEM Fuel Cell	7,000	0.01–0.05	Low	Long	Very low	Long
Molten Carbonate Fuel Cell	5,000	0.01–0.05	Low	Long	Very low	Long

Note: Fuel cell costs exclude batteries required for startup and/or backup.

Source: "New Performance Based Standards for Standby Power," Clean Energy Group, 2007; "Economic Analysis of PEM Fuel Cell Systems," Battelle Memorial Institute, 2005.

UTC POWER

Anaheim Police Department and Community Center

This 200 kW fuel cell installation is located at the East Anaheim Police Department and Community Center. The fuel cells produce enough energy to power 250 typical homes in Anaheim and any excess power is then fed back into the electric grid. It can also provide backup power to its dedicated loads in the event of a power outage.

First Responder Stations & Call Centers

During the massive blackout in New York City in August 2003, the New York Central Park Police Station remained in operation because it is powered by an on-site fuel cell that is grid-independent. Other first-responder stations across the country are beginning to adopt this model—by using clean, distributed generation to power and heat their facilities. For example, New York just completed the largest fuel cell project in the nation at the Verizon 911 call center in Long Island, and the East Anaheim Police Department and Community Center in California has installed a fuel cell system to provide power for its operations.

Hospitals

Hospitals are required by law to have a secure, resilient power supply to continue to operate critical equipment during power outages. For most hospitals, this has meant diesel generators. The Connecticut Clean Energy Fund sponsored a fuel cell installation at the Saint Francis Hospital in Hartford, CT. The St. Francis fuel cell operates in a combined heat and power application that produces up to 200 kW of baseload electricity and preheats boiler feed water with the heat recovered from the fuel cell. The fuel cell system also provides secure power in case of grid failure.

Airports

Power blackouts at airports are infrequent but extremely disruptive and costly for air traffic control, airlines, airport security, and passengers. The power outage at Reagan National Airport on January 4, 2010 was not just a local problem; it represents a national energy reliability and security problem. And it happens all too often at airports

Air to Ground Communications

The Federal Aviation Administration (FAA) launched a program in September 2009 to deploy fuel cell backup power units ranging in size between 1 kW and 4 kW (51 kW total) at 26 sites across the FAA's three service centers: east, central, and west.

The FAA has been using fuel cells at its sites since 2003 to provide backup power to air-to-ground communication and repeater equipment. This new project will provide fuel cell backup power to radio transmit receive (RTR) and air traffic control sites that are not currently using traditional backup power systems. At these sites, if grid power goes out, the site goes down, causing a disruption in communication between pilots and ground control. The high reliability of fuel cells is expected to improve communications at these locations in an environmentally responsible manner.

UTC POWER

St. Francis Hospital

St. Francis Hospital is the first hospital in Connecticut powered, in part, by a fuel cell. The PC25 cell, manufactured and installed by Connecticut-based UTC Power, generates 200 kW of electricity. It eliminates part of the hospital's dependence on the power grid and will provide supplemental power in the event of a power disruption.

around the country, unnecessarily disrupting passengers, threatening airport security, and wasting money.

Although airports have redundant power supplies including back-up generators, these can and do fail. Several airports are testing fuel-cell operated ground handling equipment. Airports should also consider the replacement of diesel generators with fuel cells for back-up power. To amortize the costs of these systems, airports should consider the installation of fuel cells large enough to provide a source of primary power for the entire facility.

Emergency Centers

According to the Department of Energy, under an extreme national disaster scenario, schools could provide a safe haven for 25 to 50 million citizens. Several state clean energy funds support on-site clean energy projects at schools that can serve as emergency shelters. If grid power is down, many of these facilities will have at least partial power to conduct emergency management operations and meet community needs. For example, South Windsor High School and Middleton High School in Connecticut are home to fuel cell systems that provide a portion of the schools' primary power under normal operations and provide grid-independent power which enable the schools to be used as emergency shelters.

Wastewater Treatment

Wastewater treatment is critical public infrastructure that needs to keep operating in the event of power loss. In addition, the biogas produced in the treatment process provides a readily available renewable fuel to power a fuel cell system, while avoiding the flaring or release of methane. To reduce air pollution and reliance on the local power grid, the Regional Wastewater Treatment Facility in Tulare, California, decided to implement a reliable and clean, onsite, distributed power resource. Tulare is home to more than 50,000 residents and the wastewater facility treats nearly 9 million gallons of water per day. The facility installed an anaerobic digester to capture methane from the wastewater treatment process, which then is used by three stationary fuel cells to provide high-quality, clean baseload power, resulting in substantial cost savings to the facility. The fuel cells have successfully addressed emissions non-attainment restrictions in place throughout California's San Joaquin Valley. The fuel cells have successfully reduced the facility's emissions as well as its reliance on the local power grid.

Policy Support for Fuel Cells in Critical Facilities

State and local governments can promote the use of fuel cells in critical facilities through a number of policies.

- Require that fuel cells be installed as primary or back-up power systems in all new public buildings and all critical use facilities (e.g., emergency dispatch centers, hospitals, water pumping, wastewater treatment). Leading by example, states and municipalities can jump-start fuel cell demand and provide visible demonstration projects. In addition, the long investment horizon for public entities allows them to finance and amortize system costs over decades, lowering the up-front financial hurdles.

- Specify performance requirements for back-up power (for example, emissions, reliability, operating time) that are more rigorous than those that lead to the selection of diesel generators as the default technology and that are best met by fuel cells.
- Provide state incentives and/or financing to support the installation of fuel cells for these critical facilities.
- Develop federal-state partnerships to fund installations and facilitate joint procurement.

Conclusions

Reliable sources of standby and primary power are essential for the tens of thousands of facilities—from telecommunications towers to hospitals and data centers—for which even brief interruptions of power can have significant impact. Fuel cells are an ideal source of both primary and standby power for these applications. They are clean, quiet, reliable, and produce consistent, high-quality power. They are also cost-effective relative to other technologies on a life-cycle basis.

State policies should recognize the advantages of fuel cells for these critical facilities and encourage or require their installation as new facilities are built or renovated. This is not part of "worst case" disaster planning. Rather, snow and ice storms, transformer damage and human error can all result in power outages lasting from a few minutes to many days. Regardless of the cause, fuel cells should be part of the solution in protecting our communities' critical infrastructure when the power goes out.

Backup Power Requirements

State and local codes for emergency and back-up power requirements generally follow the National Fire Protection Association's (NFPA) National Electrical Code (NEC). NEC Article 708, first included in 2008, covers Critical Operations Power Systems ("COPS") and is the most comprehensive and stringent set of standards for back-up power established to date. NEC Article 708, developed in response to the 2003 power blackout in the Northeast and Hurricanes Katrina and Rita, covers any facility that, if incapacitated, would disrupt national security, the economy, public health and/or safety. Local jurisdictions have the authority to designate a facility as a COPS. Potential facilities include air traffic control centers; fire and security system monitoring; hazardous material handling facilities; communication centers and telephone exchanges; emergency evacuation centers; financial, banking, business data processing facilities; fuel supply pumping stations; hospitals; water and sewage treatment facilities; 911 centers; critical government facilities; police, fire and civil defense facilities including power for radio repeater operations; radio and TV stations; and transportation infrastructure.

NEC 708 specifies that these facilities or critical components of these facilities must be capable of restoring power within ten seconds and running for up to 72 hours (3 days) on back-up power. NEC 708 specifically designates generators, uninterruptable power supply or *fuel cell systems* with adequate fuel supply as meeting these requirements. For more information, refer to page 70-609 of the NEC 2008 Edition (available at *www.nfpa.org*) or for an overview of Article 708, see *http://www.geindustrial.com/Newsletter/cops.pdf.*

FUELCELL ENERGY

Tulare Regional Wastewater Treatment Plant

By utilizing digester gas as an onsite renewable energy source, Tulare received $4 million in financial incentives from California's Self-Generation Incentive Program (SGIP) and avoided paying $600,000 in state Emission Reduction Credits that would have been required if it had used combustion equipment. This combined heat and power configuration uses three FuelCell Energy DFC 300™ Fuel Cells.




CleanEnergy States Alliance

Clean Energy States Alliance (CESA) is a national nonprofit coalition of state clean energy funds and programs working together to develop and promote clean energy technologies and markets. CESA provides information sharing,technical assistance services and a collaborative network for its members by coordinating multi-state efforts, leveraging funding for projects and research, and assisting members with program development and evaluation.

Many states across the U.S. have established public benefit funds to support the deployment and commercialization of clean energy technologies. More than twenty states are actively participating in CESA membership activities. Though these clean energy funds, states are investing hundreds of millions of public dollars each year to stimulate the technology innovation process, moving wind, solar, biomass, and hydrogen technologies out of the laboratory and toward wider use and application in business, residential, agricultural, community and industrial settings. State clean energy funds are pioneering new investment models and demonstrating leadership to create practical clean energy solutions for the 21st century.

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