Fuel Cells for Resilience and Decarbonization in California

November 24, 2019
California Policy Priorities

Decarbonization

Resilience and Public Safety Power Shutoffs

Increased penetration of renewables

Zero emission transportation and goods movement

Community health risk mitigation

GHG reduction & air quality improvement
Fuel Cells Provide Clean, Resilient Power

Significant System Benefits

- Load-following and islanding capabilities
- Firm, reliable source of 24/7 clean power
- Scalability to meet local system needs
- Improved power quality
- Very high system efficiencies

Behind-the-Meter Distributed Generation

Large-Scale Utility Generation Resources

Distribution System Resources

TIGER Stations
(Transmission Integrated Grid Energy Resource)
Stationary Fuel Cells in Microgrids

- Increased resilience with local backup power and load management
- Connect or island from central grid
- High efficiency
- Balance intermittent resources
- No pollutant emissions
- Power purchase agreements eliminate end user risk
- Reduce operating costs and avoid T&D investment

Photo courtesy of FuelCell Energy
Town of Woodbridge, Connecticut

- Fuel cell microgrid supplies grid and maintains power during outage for 6 critical town buildings
- 2.8 MW FuelCell Energy system has blackstart capability and provides heat to a local high school
- Critical loads are sequenced by microgrid controller and inverter follows microgrid load
Fuel Cells for Military Microgrids

Naval Submarine Base, Groton, Connecticut Multi-Microgrid

- 7.4 MW FuelCell Energy system in grid parallel operation to support critical operations during outage
- Inverter follows microgrid load and load-leveler maintains constant fuel cell power
- Power purchase agreement to submarine base
- Full commercial operation in May 2019
University of Bridgeport (UB) Connecticut Fuel Cell-Only Microgrid

- Serves a 5,600 student campus
- PPA to UB creates $300,000 annual savings. NRG owns FuelCell Energy power plant.
- 1.4MW baseload with steam generation for CHP – heat to campus
- Baseload, net metering
- Black-start capability
Fuel Cells for Municipal Microgrids

City of Hartford, Connecticut Fuel Cell-Only Microgrid

- Constellation Energy providing engineering, procurement, construction and operation services for an 800 kW Bloom Energy system.

During non-emergency and emergency operation, the microgrid provides 100% of electricity needed.

In the event of power outage, the system also provides emergency power to a local fuel station and grocery store.

Excess electricity generated by the system reduces electricity costs at four Hartford schools.
Fuel Cells for Municipal Microgrids

Video Source: https://www.youtube.com/watch?time_continue=5&v=2gMv-Diaxow
Marcus Garvey Village Microgrid for Air Quality

Solar + Storage + Fuel Cell Microgrid Reduces Emissions and Increases Resiliency at Low-Income Housing Development in Brooklyn

Project Overview
• 480 kW solar, Bloom Energy 400 kW fuel cell and 300 kW/1.2 MWh lithium battery
• Fuel cell serves as "anchor" generator for microgrid

Benefits
• Energy cost savings, resilient microgrid for Marcus Garvey residents
• Grid Benefits: Targeted load reduction, grid reliability, reduced emissions with ratepayer savings

Overall ConEd Initiative
• Saved Ratepayers Nearly $1 Billion while Reducing Emissions and Alleviating Grid Congestion
• 6.2MW of fuel cells deployed across six locations within targeted load relief area
• Brooklyn Queens Demand Management Portfolio of Fuel Cell Projects Eliminates 25,053 lbs of NOX from New York City annually

EMISSIONS REDUCTIONS

<table>
<thead>
<tr>
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<th>Annual CO₂ Emissions Reductions</th>
<th>Annual NOx Emissions Reductions</th>
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<tr>
<td>400 kW Fuel Cell</td>
<td>1,077,854 lbs/year</td>
<td>1,643 lbs/year</td>
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<tr>
<td>400 kW Solar</td>
<td>522,496 lbs/year</td>
<td>233 lbs/year</td>
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Fuel Cells for Seamless Load Transfer & Backup Power

October 2012 Hurricane Sandy
- All 23 fuel cell in the impacted areas remain operational during the storm

CT October 2011 Winter Storm Alfred
- Doosan fuel cell systems
- South Windsor, CT High School serves as community shelter
- Whole Foods Market avoids costly food spoilage
- CT Juvenile Training Facility operated continuously
Fuel Cells for Critical Power

Albertson’s Supermarket (San Diego, CA)

- 400 kW Doosan fuel cell system
- Electric load-following with net metering
- Heat recovery for space heating, space cooling, domestic hot water
- Backup power for refrigeration – perishable inventory protected

September 2011 San Diego Blackout

- One of the few retail stores operating in the valley
- Provided essential services and goods to the community
Demonstrated Resilience

Hurricanes Sandy, Joaquin and Irma

Sustained winds and storm surges tested Altergy’s backup power systems, which ran continuously until local power was restored.

Napa Earthquake

Altergy’s backup power systems powered through the earthquake and suffered no damage or interruptions to service after the earthquake.
Demonstrated Resilience

Hurricane IRMA: September 2017

- Altergy fuel cells remained to power through the storm in the Bahamas
- Operational sites remained powered until re-fueled or fuel supply ran out
- Methanol reformer fuel with standard tank provides days of runtime critical for natural disaster recovery communications
Demonstrated Resilience

Hurricane Joaquin in the Bahamas: September 2015
- Damages: $200 million USD
- Total Fatalities: 34
- Backup power Altergy fuel cell systems ran continuously through the category 4 hurricane with sustained 130 mph wind and storm surges until local power was restored.
Demonstrated Resilience

Bloom Energy Servers

Hurricane Sandy
10/29/12

CA Earthquake
8/24/14

Data Center Utility Outage
4/16/15

Napa Fire
10/9/17

Physical Damage
11/21/16

Japanese Super-Typhoon
10/23/17

Photo courtesy of FuelCell Energy

Fuel Cell for Resilience and Decarbonization
Demonstrated Resilience
Fuel cell systems run continuously during 2019 outages

Ridgecrest Earthquakes
7/4-5/19

Manhattan Blackout
7/13/19
Large-Scale Fuel Cell Systems For Resilience, Grid Services and Clean Air

Utilities - US

- New Britain CT – 20 MW Energy Improvement Park
  - Reliability for new state of art data center

- South Windsor, CT – 5 MW
  - Resiliency and power for 15,000 homes

- Bridgeport, CT – 14.9 MW – Dominion Energy
  - Resiliency and power for 15,000 homes

- Newark, DE – 30 MW – Constellation Energy
  - 2 Delmarva substations
  - Power for 22,000 homes

  - Resilient combined cooling, heat and power and small footprint

Utilities – South Korea

- Hwasung City, South Korea – 59 MW – Gyeonggi Green Energy
  - On 5.2 acres and supplies grid power and district heating

- Daesan, South Korea – 50 MW – Hanhwa Energy, Korea East West Power

- Incheon, South Korea – 20 MW CHP – KOSPO

- Busan, South Korea - 30.8 MW CHP – Korea South-East Power
  - District heating and power for 71,500 homes

Busan Green Energy Project: 30.8MW, photo courtesy of Doosan
Renewable Fuel Cells in Microgrids

University of California, San Diego

- System operates with 3 MW roof top solar PV intermittent contribution
- Load-following by 30 MW gas turbine generators
- 2.8 MW directed biogas Fuel Cell Energy fuel cell serves baseload and treats turbines as grid

Photo courtesy of FuelCell Energy
Fuel Cells for Campus Decarbonization

UC Irvine Medical Center’s 1.4 MW FuelCell Energy system and absorption chiller microgrid system

- Generates ~30% of the facility's power needs
- Supplies 200 refrigeration tons of cooling (800 kW)
- Avoids the annual emission of:
  - 28 tons of nitrogen oxide (NOx)
  - 64 tons of sulfur dioxide (SOx)
  - 3,000 pounds of particulate matter (PM10)
  - 7,000 tons of CO₂
Fuel Cell Systems For Decarbonized Critical Power

Challenges

- eBay’s Data Center in Utah loses $6,000 per second of downtime
- The company’s sustainability mission was in conflict with UT’s electric grid which sources 80% of it’s electricity from coal

Solution

- 6 MW of Bloom Energy fuel cell systems provide primary, onsite, reliable power matched to the operational requirements of the data center
- System provides 100% of electricity demand while drastically reducing carbon footprint

How it works

- Redundant, modular architecture provides highly reliable power
- System architecture replaces large and expensive backup generators and UPS components
Fuel Cells for Dispatchable Load Following

- Coca-Cola bottling facility
- 5 day/week production facility
- 400 kW baseload weekdays
- Load-following with 100 kW minimum utility import on weekends

- Whole Foods Market
- Supermarket
- Continuous load-following
- Net-metering with zero utility power import
Fuel Cells for Decarbonization

UC Irvine full grid simulations

SGIP FC fleet data
Stationary Fuel Cells Reduce Pollutants

UC Irvine full grid simulations

SGIP fuel cell fleet data
Fuel Cells Achieve California’s Energy & Climate Goals

Fuel cells interconnect to the grid to provide:

- Decarbonization
- Air Quality Improvement
- Islanding for De-energization
- Resilience
- Grid Support and Ancillary Services