

Fuel Cells for Resilience and Decarbonization in California

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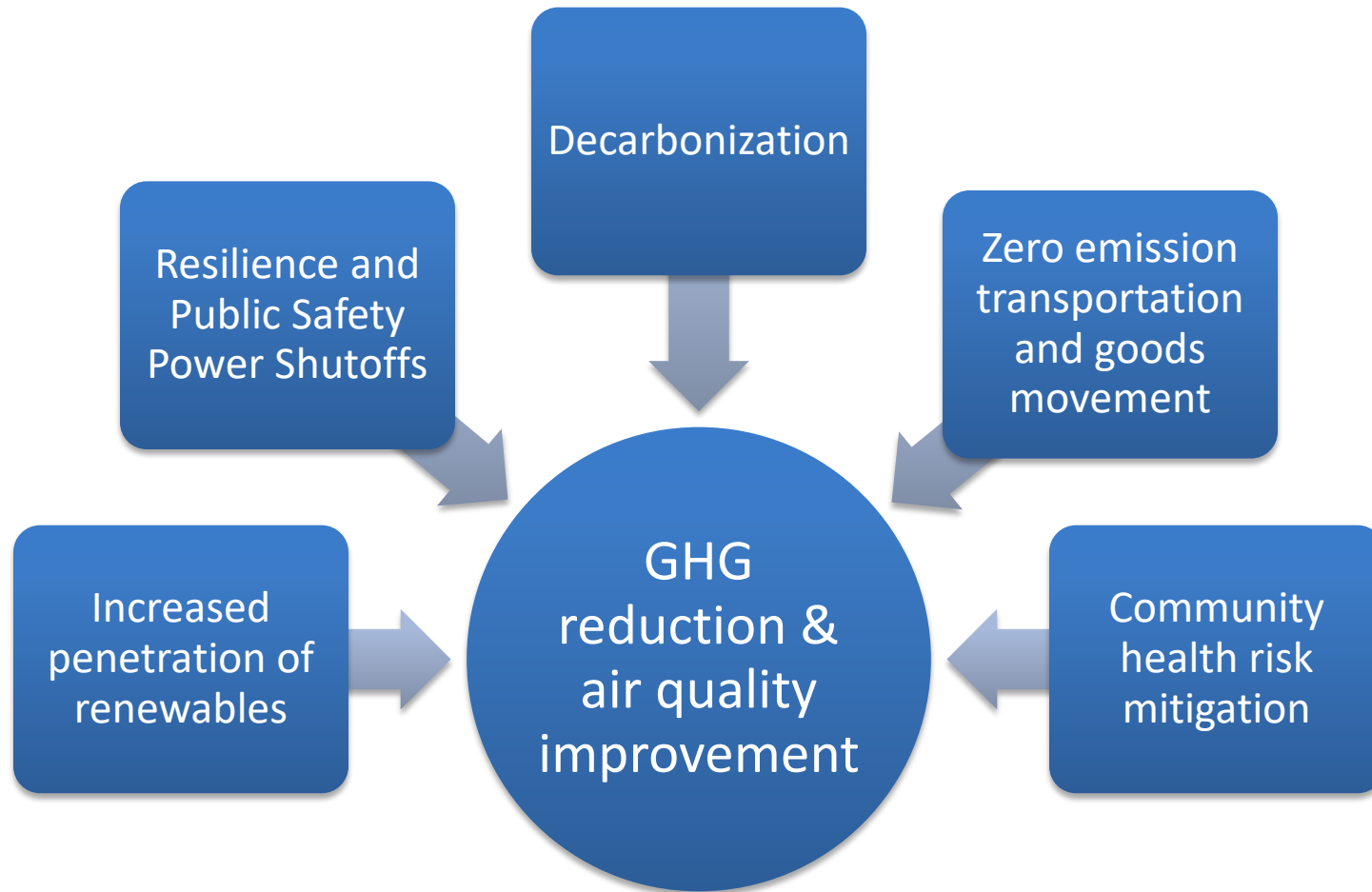
December 12, 2019



**California Stationary
Fuel Cell Collaborative**



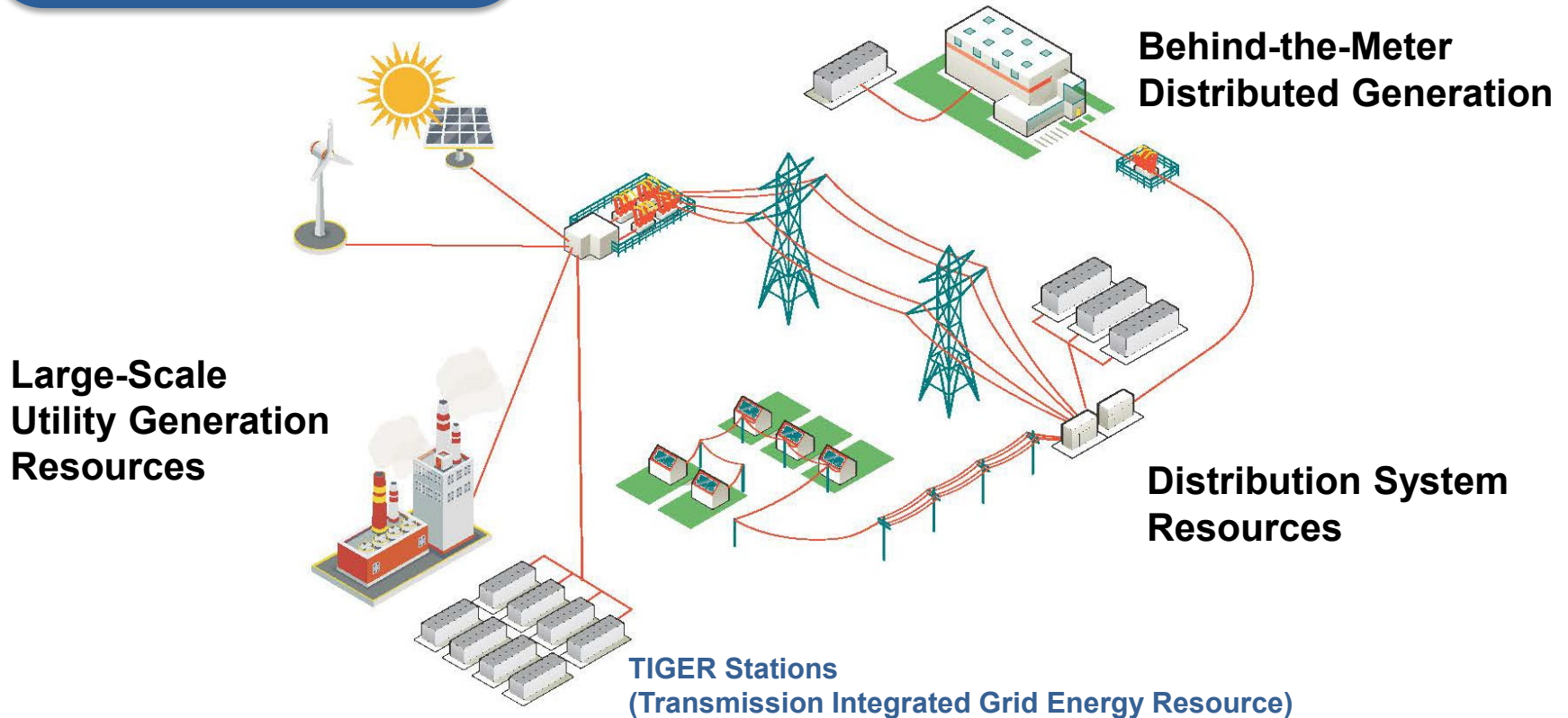
California Policy Priorities



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



Stationary Fuel Cells in Microgrids

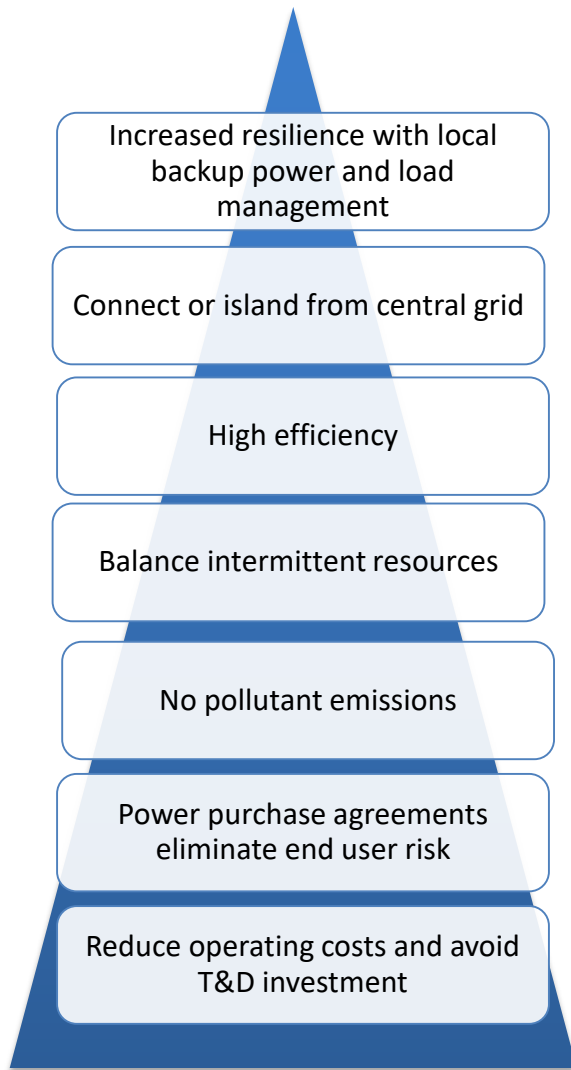
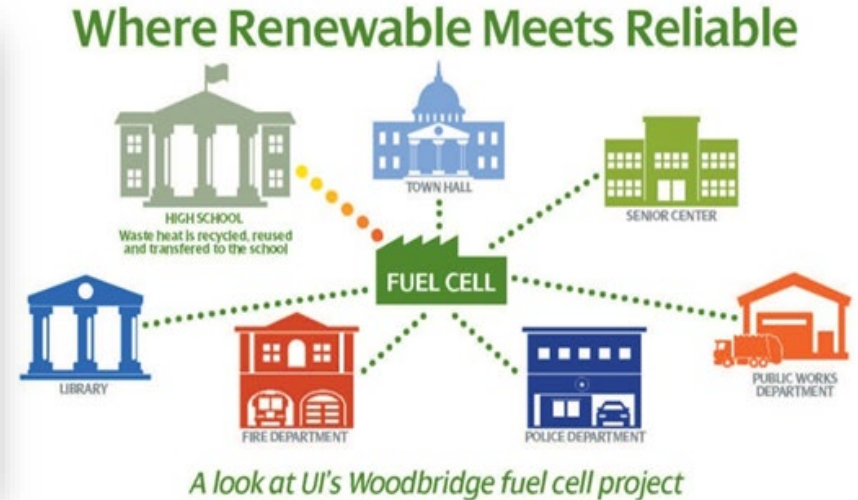


Photo courtesy of FuelCell Energy

Fuel Cells in Utility Microgrids



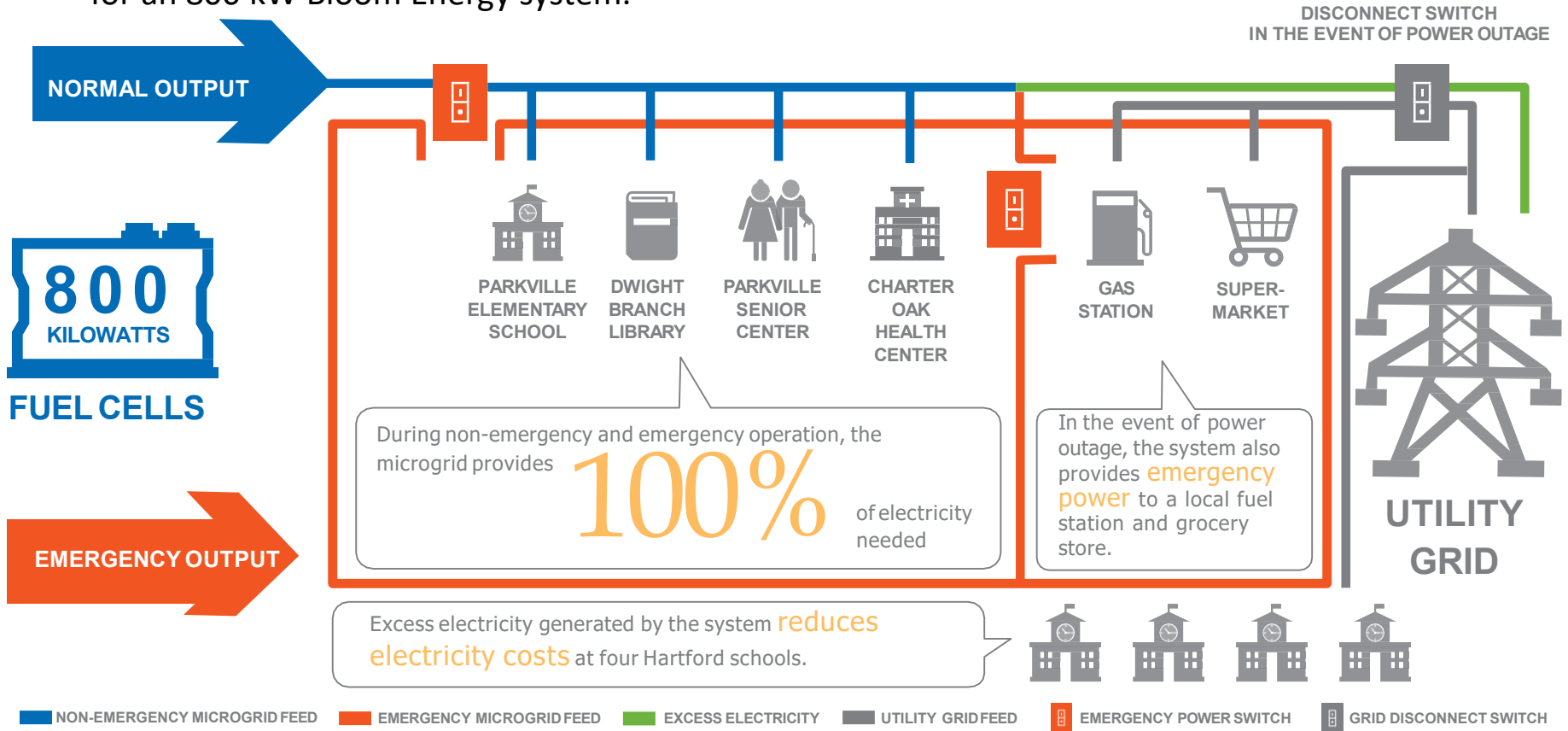
Town of Woodbridge, Connecticut

- 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 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.



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

EMISSIONS REDUCTIONS

	Annual CO ₂ Emissions Reductions	Annual NOx Emissions Reductions
400 kW Fuel Cell	1,077,854 lbs/year	1,643 lbs/year
400 kW Solar	522,496 lbs/year	233 lbs/year



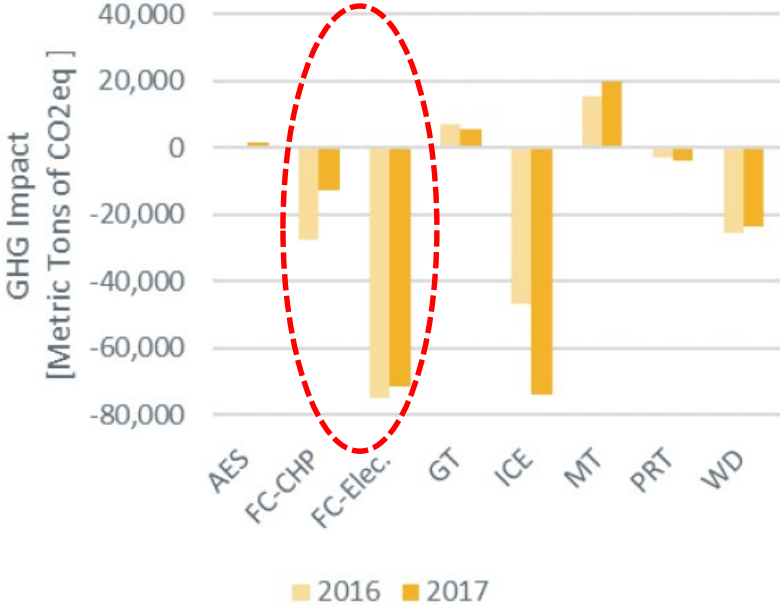
Overall ConEd Initiative

- 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

Fuel Cell Emissions Reduction Quantified

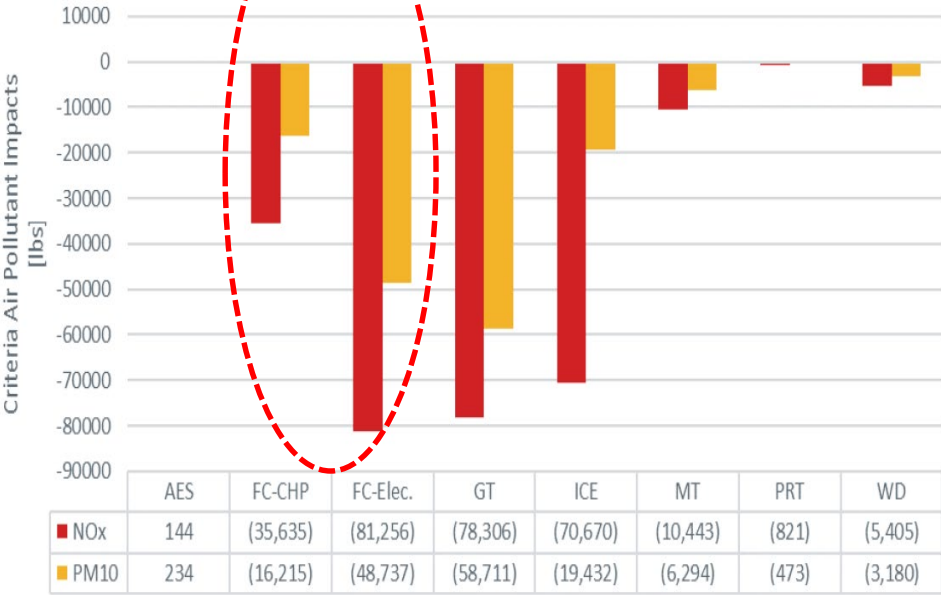
GHG Reductions

By Technology Type and Year (A)



Criteria Air Pollution Reductions

FIGURE ES-4: CRITERIA AIR POLLUTANT IMPACTS BY TECHNOLOGY TYPE (2017)



Source: SGIP 2016-2017 Impact Report, Table ES-6: GHG Impacts by Technology Type and Year and Figure ES-4 Criteria Air Pollutant Impacts By Technology Type (2017)



Emission Sources vs. Fuel Cells

Cellular Telecoms and Cable/Data Operators (MSO's) utilize batteries and small generators (<35kW) to provide continuous connectivity/power

- Batteries cannot provide prolonged runtime, so critical sites have a small generator
- Small generators have no or almost no emissions mitigation equipment

Comparison of emission factors on a pound per megawatt hour (lb/MWh) basis

Emission Factor (lb/MWh)

Power source	NO _x	SO ₂	CO ₂
WECC California Grid[a]	0.86	0.06	985
Tier 4 Diesel Emergency Generator, 250 kW	0.88	0.016	1,542
Bloom Energy Server, 250 kW	0.0017	Negligible	756

Source: Ramboll, *Grid + Diesel Backup Emissions Compared to Bloom Energy Servers in California*, October 2019.

Backup Power Solutions



Small backup power fuel cell systems (5 kW-100 kW) reduce risk by ensuring that communications, data transfer, traffic signals and railroad crossings are operating during extended outages

Hurricanes Sandy, Joaquin and Irma

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

Napa Earthquake

Alteryg's backup power systems powered through the earthquake and suffered no damage or interruptions to service after the earthquake.

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

Brookhaven, NY – 39.8 MW – PSEG/Long Island Power Auth.

- Resilient combined cooling, heat and power and small footprint



Busan Green Energy Project: 30.8MW, photo courtesy of Doosan

Utilities – South Korea

Hwasung City, South Korea – 59 MW – Gyeonggi Green Energy

- On 5.2 acres and supplies grid power and district heating

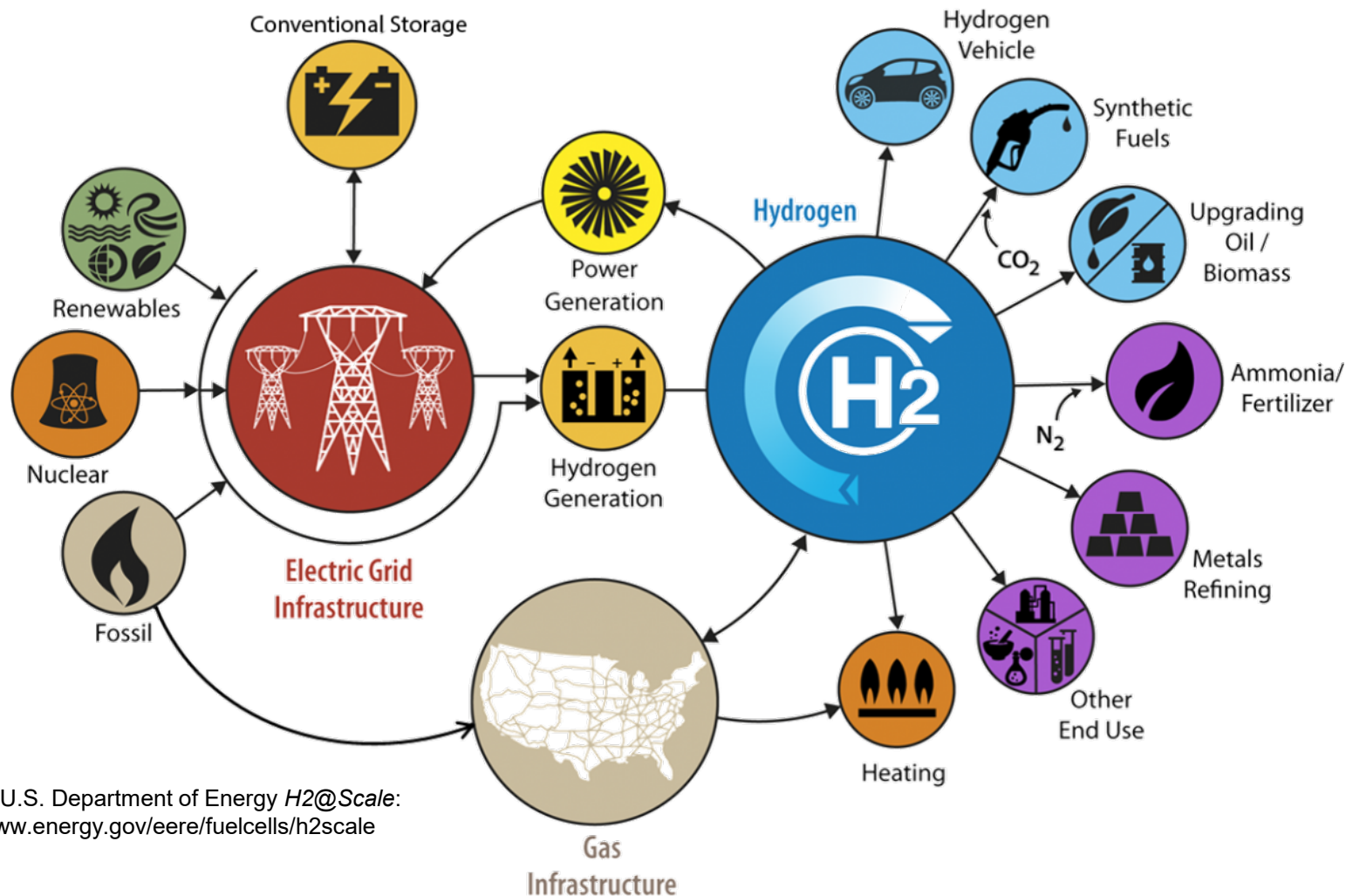
Daesan, South Korea – 50 MW – Hanhwa Energy, Korea East West Power

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

Wide-scale Hydrogen Production and Utilization for Resilience



Source: U.S. Department of Energy *H2@Scale*:
<https://www.energy.gov/eere/fuelcells/h2scale>

Enabling Policy for Resilient Solutions

Short-term (early 2020)

1. Establish microgrid tariff for behind-the-meter systems by April 2020:
 - Address departing load charges
 - Reduce standby charges
 - Streamline interconnection of one microgrid with multiple technology solutions
 - Size generation to accommodate additional loads during emergency situations and eliminate nameplate capacity restrictions.
2. Consider air quality and community-level impacts in evaluating solutions
3. Consider full valuation of environmental and performance attributes in cost analysis (for backup power as well as primary generation)

Mid-term (mid-2021)

- Allow adjacent facilities to participate in a common microgrid for benefit of utility. Also allows creation of local resiliency centers.

Long-term (Beyond 2021)

1. Support for production and availability of renewable fuels, including biofuels and renewable hydrogen
2. Mandates for low- and zero-emission non-combustion generation
3. Enable community microgrids by allowing use of utility transmission lines to serve multiple meters and customers
4. Address exporting excess power and compensation with utilities

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www.casfcc.org



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Backup Slides

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Alteryx has a clean backup power solution to critical safety and communication infrastructure

- Alteryx can power critical intersections, cell towers and RR crossings
 - Fuel cells convert hydrogen into electricity without combustion
 - CARB certified zero emissions
 - Eliminates well documented issues with batteries and generators
 - Batteries have short run times and unpredictable life
 - Generators have reliability, emissions issues, are noisy and are susceptible to theft



Telecom



Traffic Signals



RR Crossings



MSO-VoIP

Benefits of fuel cell backup power

- 24/7/365 conditioning and regulation of commercial power keeping sensitive traffic signal control & ITS equipment working properly & safely
- Keep your traffic signals and ITS systems running during power outages
- With hydrogen re-fueling, “unlimited” runtime in the event of extended outages
- Maintain safe traffic flow and intersection safety for pedestrians
- Minimal system maintenance, reducing your annual operating expenses
- Avoid unpredictable battery runtimes, life, & capacity issues

Fuel Cells for Campus Decarbonization

University of California, San Diego

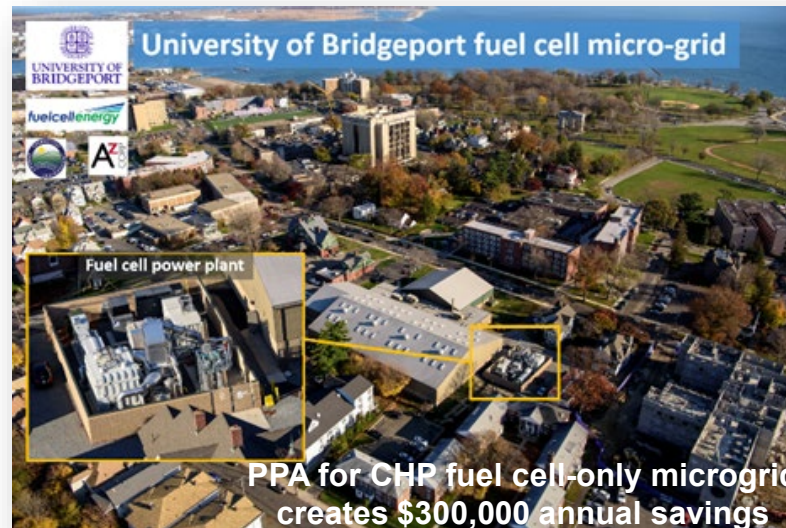


2.8 MW directed biogas fuel cell

UC Irvine Medical Center



1.4 MW fuel cell and absorption chiller microgrid system



University of Bridgeport fuel cell micro-grid

Fuel cell power plant

PPA for CHP fuel cell-only microgrid creates \$300,000 annual savings

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 2020

Demonstrated Resilience

San Diego Blackout
9/28/11

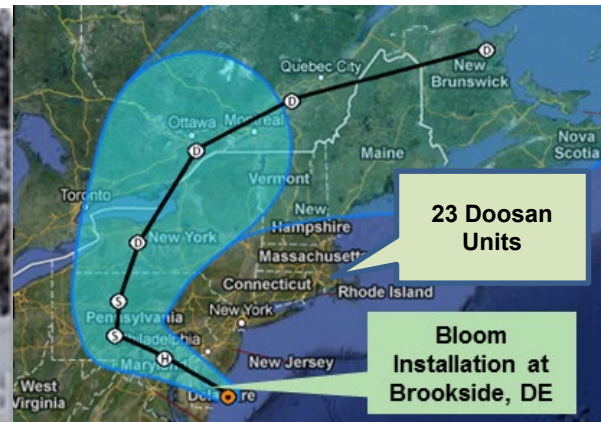


Winter Storm Alfred
10/29/11

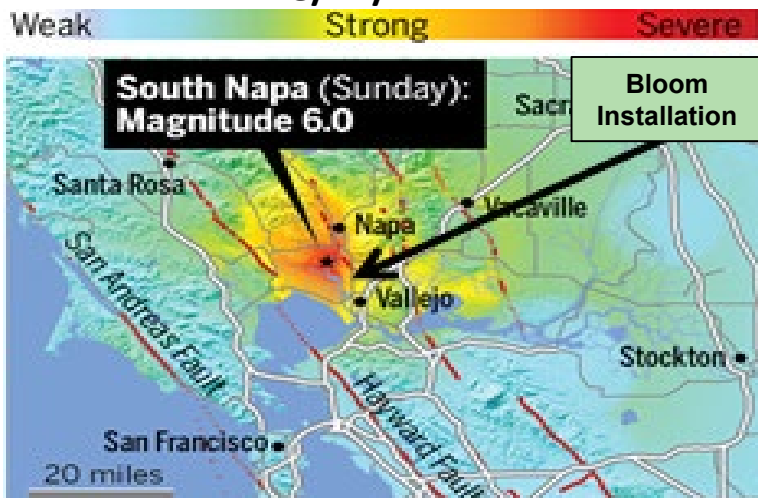


Fuel Cells for Food, Shelter and Comms

Hurricane Sandy
10/29/12



CA Earthquake
8/24/14



Data Center Utility Outage
4/16/15



Demonstrated Resilience

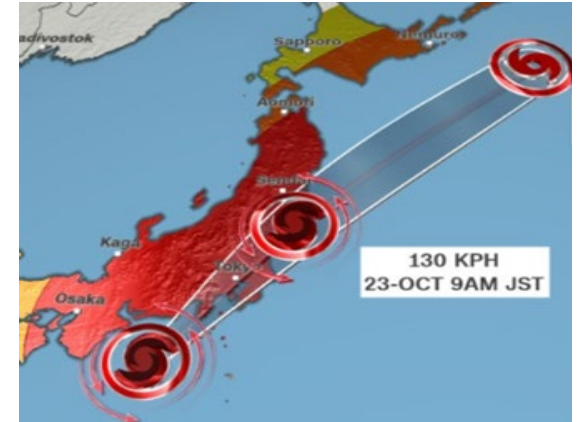
Physical Damage
11/21/16



Napa Fire
10/9/17



Japanese Super-Typhoon
10/23/17



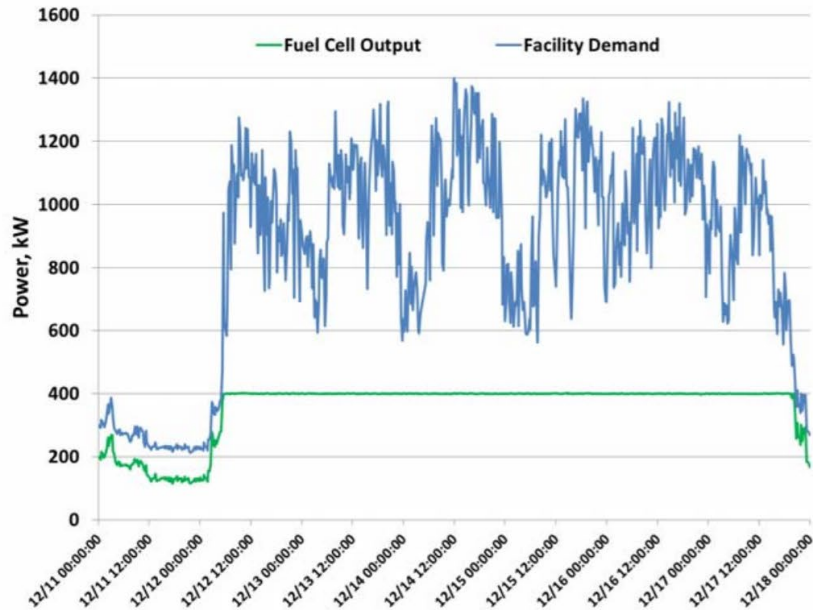
Ridgecrest Earthquakes
7/4-5/19



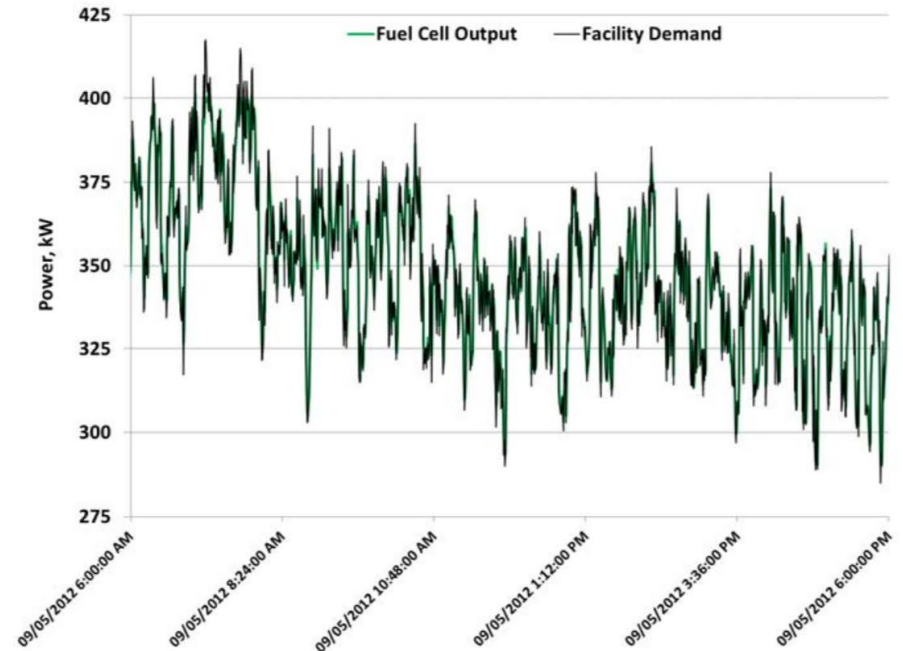
Manhattan Blackout
7/13/19



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