

Fuel Cells for Resiliency and Decarbonization in California

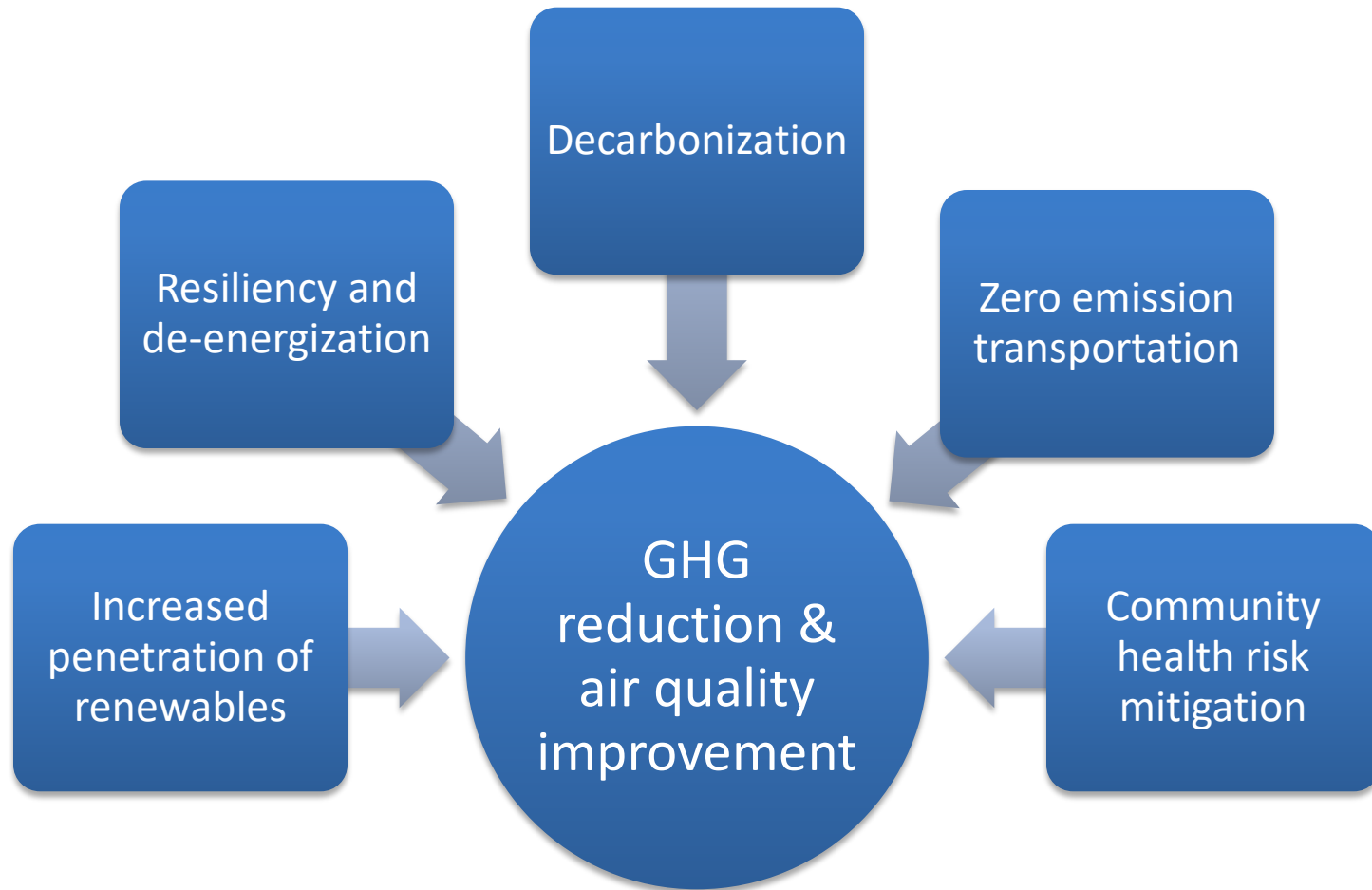
April 1, 2019



**California Stationary
Fuel Cell Collaborative**



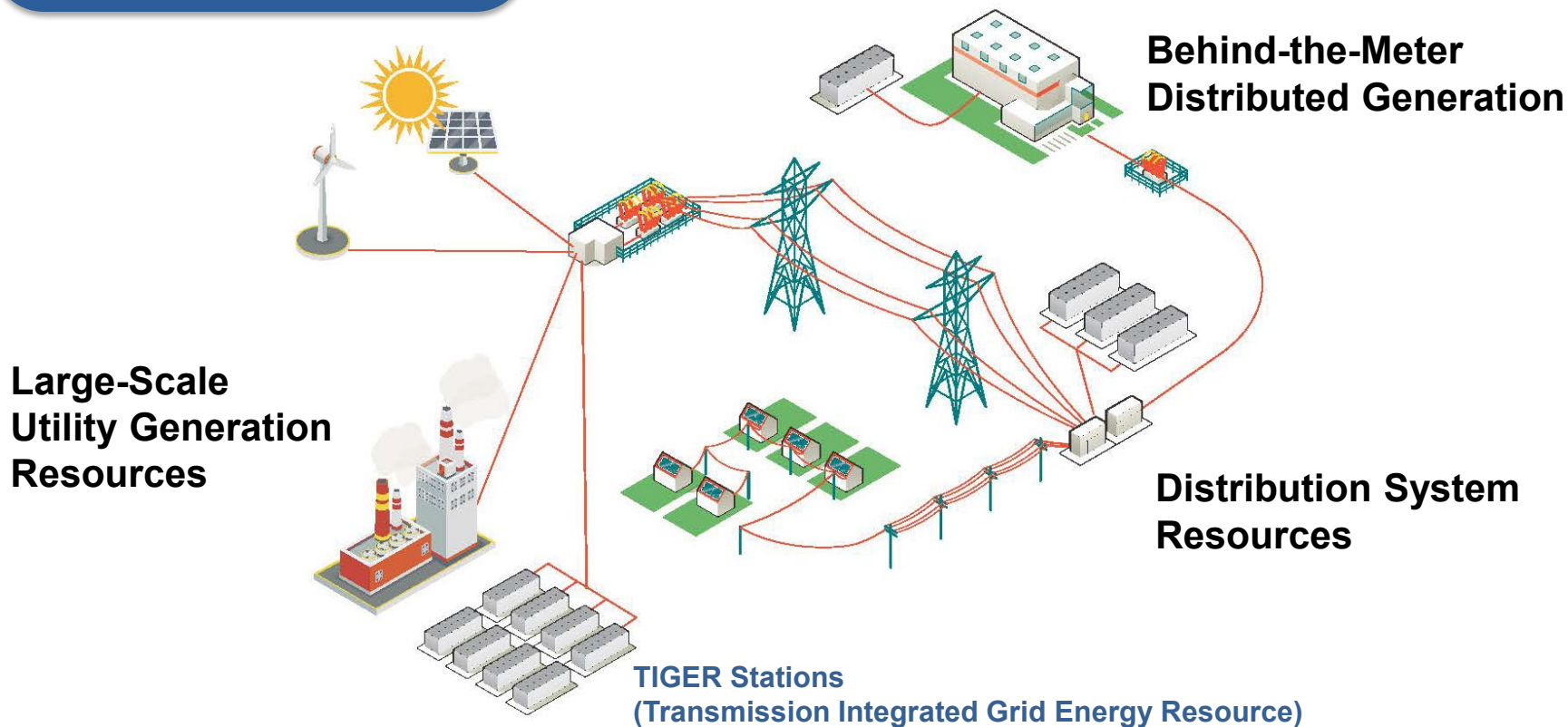
California Policy Priorities



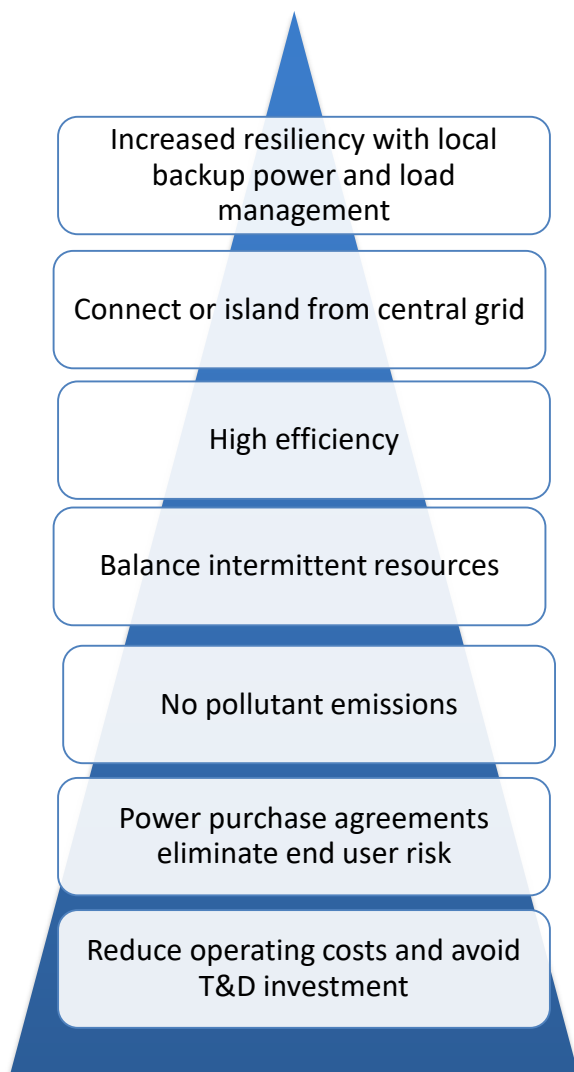
Fuel Cells Provide Clean, Resilient Power

Significant System Benefits

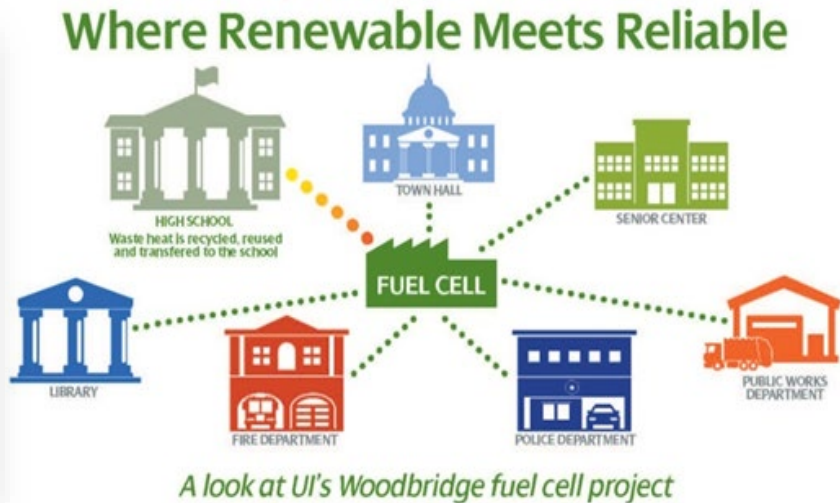
- Load-following and islanding capabilities
- Firm, reliable source of 24/7 clean power
- Scalability to meet local system needs
- Improved power quality
- Very high system efficiencies



Stationary Fuel Cells in Microgrids



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 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 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

Fuel Cells for Campus Microgrids



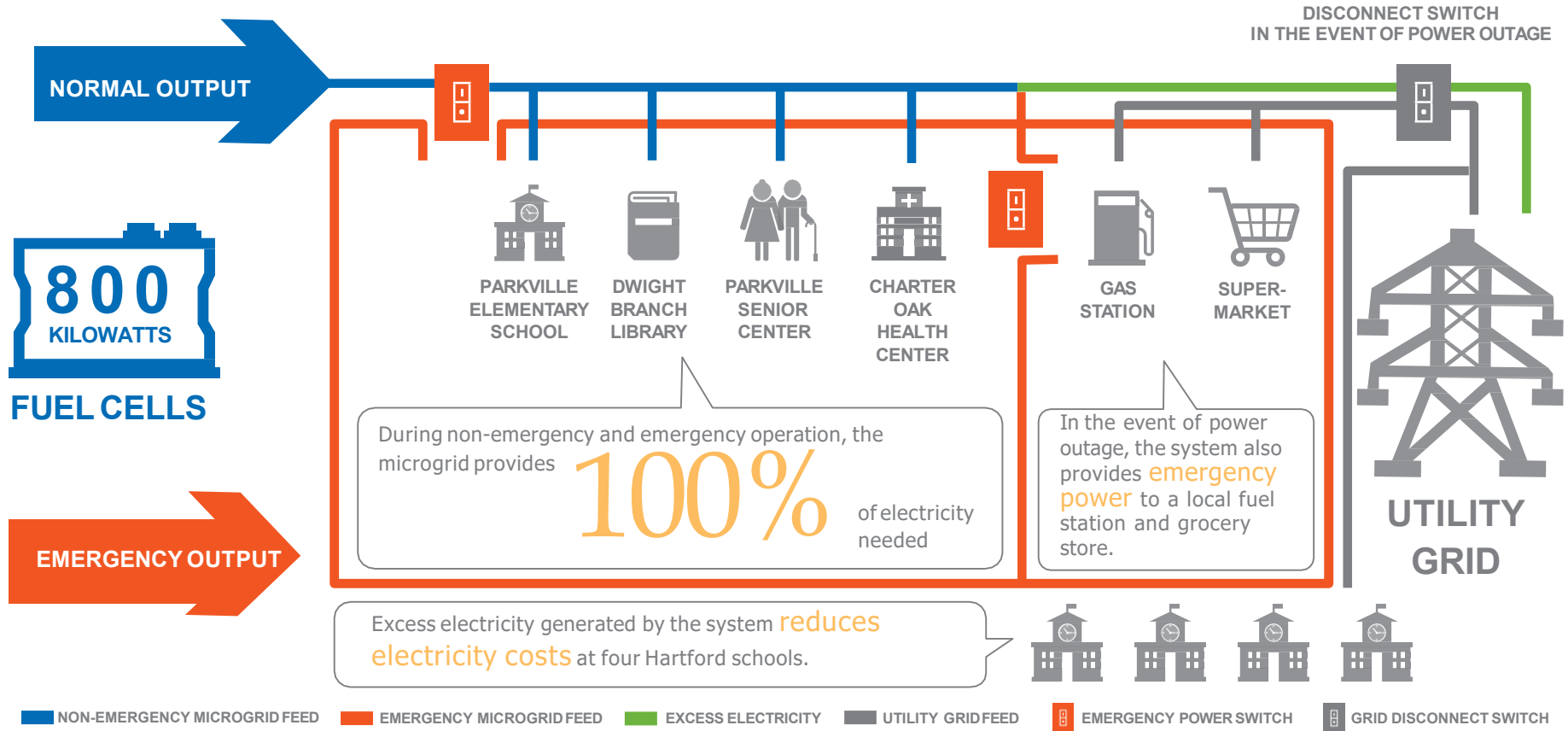
University of Bridgeport (UB) Connecticut Fuel Cell-Only Microgrid

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

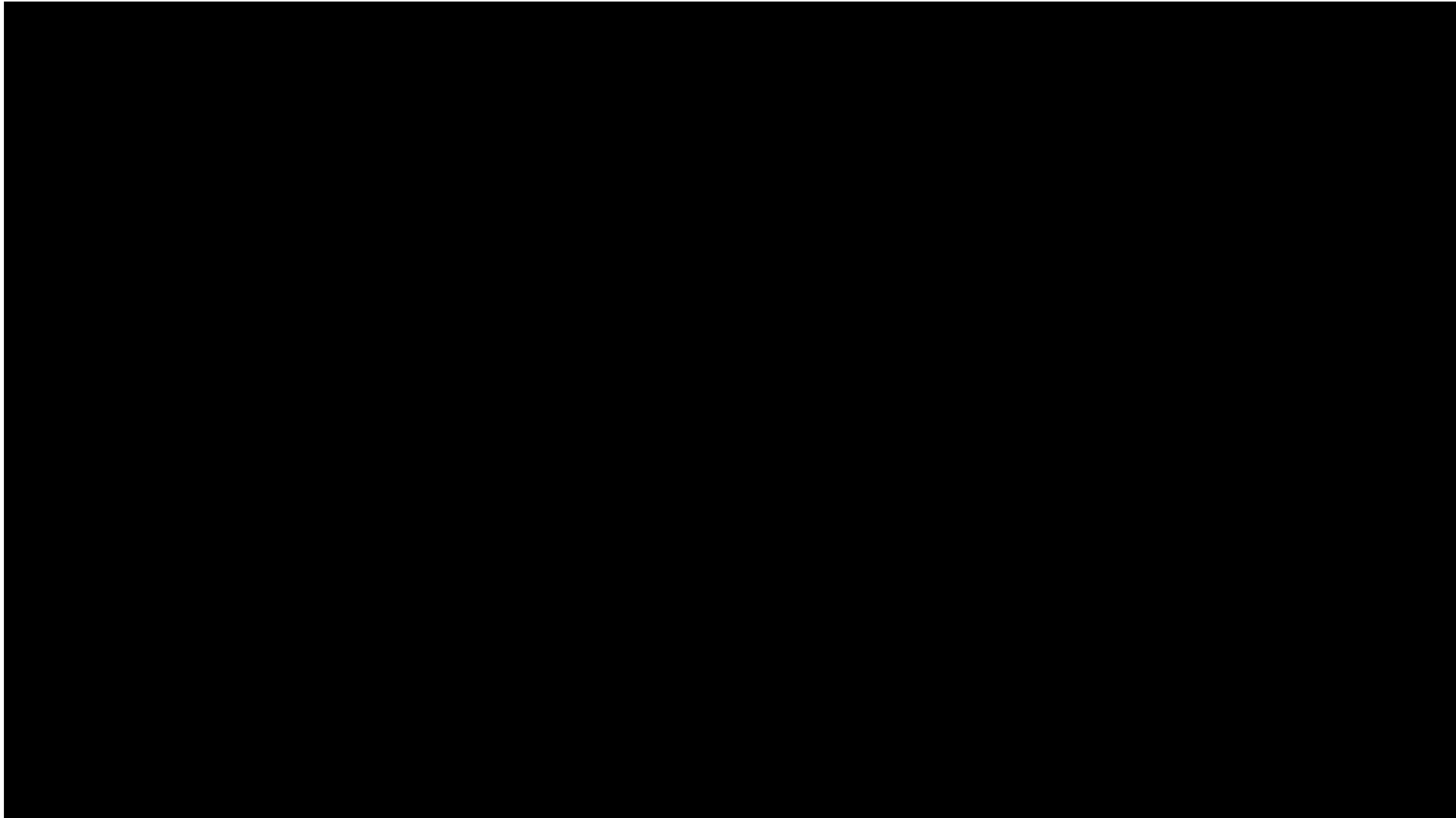
Fuel Cells for Municipal Microgrids

City of Hartford, Connecticut Fuel Cell-Only Microgrid

- Constellation Energy providing engineering, procurement, construction and operation services



Fuel Cells for Municipal Microgrids



Video Source: https://www.youtube.com/watch?time_continue=5&v=2gMv-Diaxow

Fuel Cells for Seamless Load Transfer & Backup Power



October 2012 Hurricane Sandy

- All 23 fuel cells in the impacted areas remained operational during the storm



CT October 2011 Winter Storm Alfred

- South Windsor, CT High School serves as community shelter
- Whole Foods Market avoids costly food spoilage
- CT Juvenile Training Facility operates continuously



San Diego, CA September 2011 Blackout

- Albertsons Supermarket remains open for business
- Perishable inventory protected

Fuel Cells for Critical Power

Albertson's Supermarket (San Diego, CA)



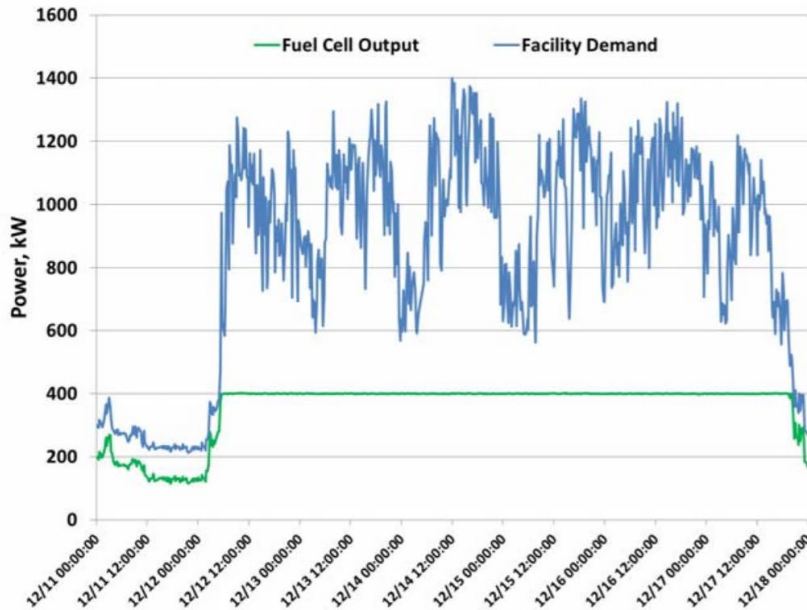
- 400 kW fuel cell system
- Electric load-following with net metering
- Heat recovery for space heating, space cooling, domestic hot water
- Backup power for refrigeration – perishable inventory protected

September 2011 Blackout

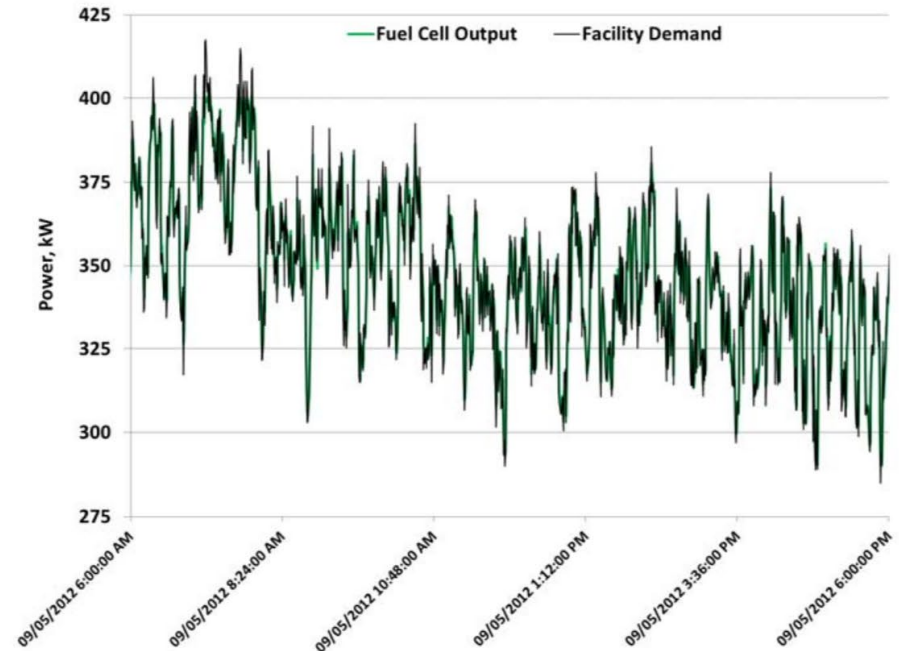
- One of the few retail stores operating in the valley
- Provided essential services and goods to the community



Fuel Cells for Dispatchable Load Following



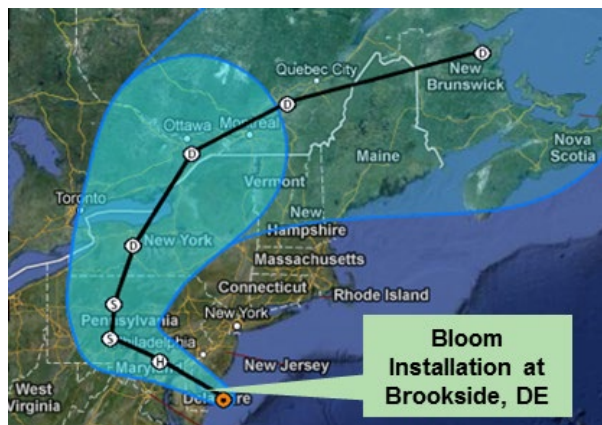
- Coca-Cola bottling facility
- 5 day/week production facility
- 400 kW baseload weekdays
- Load-following with 100 kW minimum utility import on weekends



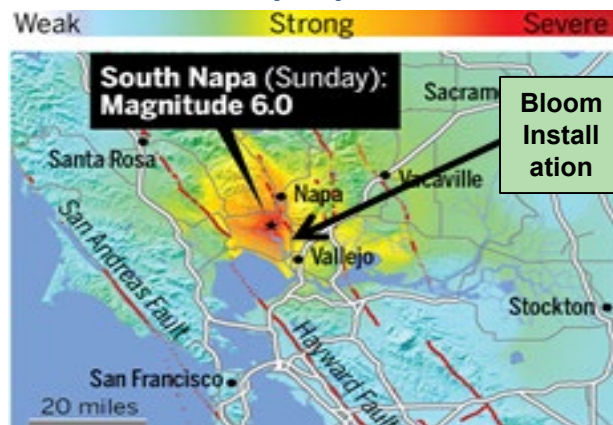
- Whole Foods Market
- Supermarket
- Continuous load-following
- Net-metering with zero utility power import

Proven Resiliency in the Field

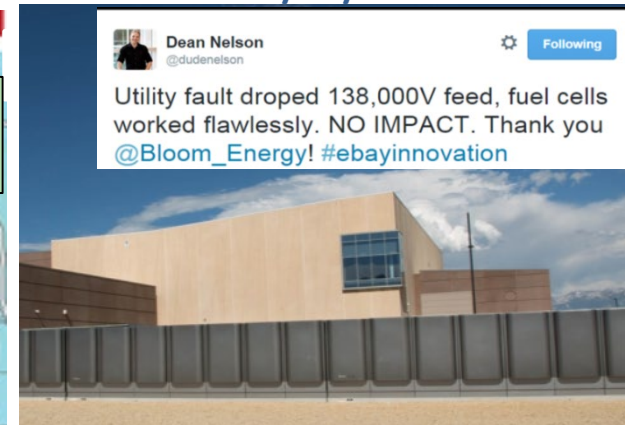
Hurricane Sandy
10/29/12



CA Earthquake
8/24/14



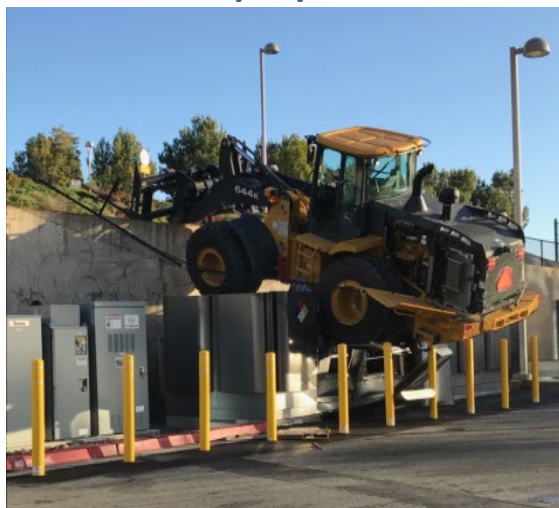
Data Center Utility Outage
4/16/15



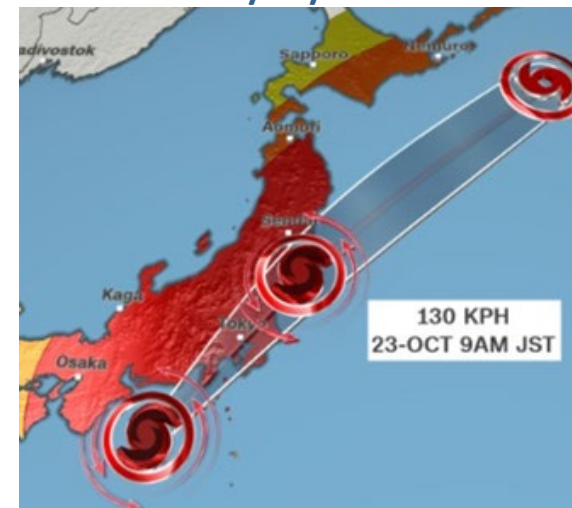
Napa Fire
10/9/17



Physical Damage
11/21/16



Japanese Super-Typhoon
10/23/17



Large-Scale Fuel Cell Systems For Resiliency, Grid Services and Clean Air

Utilities

Bridgeport, CT – 14.9 MW – Dominion Energy

- Resiliency and power for 15,000 homes

Newark, DE – 30 MW – 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

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

- Direct hydrogen for combined heat and power to local utility

Incheon, South Korea – 20 MW CHP – KOSPO

- Announced September 5

Busan, South Korea - 30.8 MW CHP – Korea South-East Power

- District heating and power for 71,500 homes



Renewable Fuel Cells in Microgrids

University of California, San Diego

- 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 serves baseload and treats turbines as grid



Fuel Cells for Campus Decarbonization



UC Irvine Medical Center's 1.4 MW fuel cell 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 (NO_x)
 - 64 tons of sulfur dioxide (SO_x)
 - 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 its electricity from coal

Solution

- 6 MW of 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

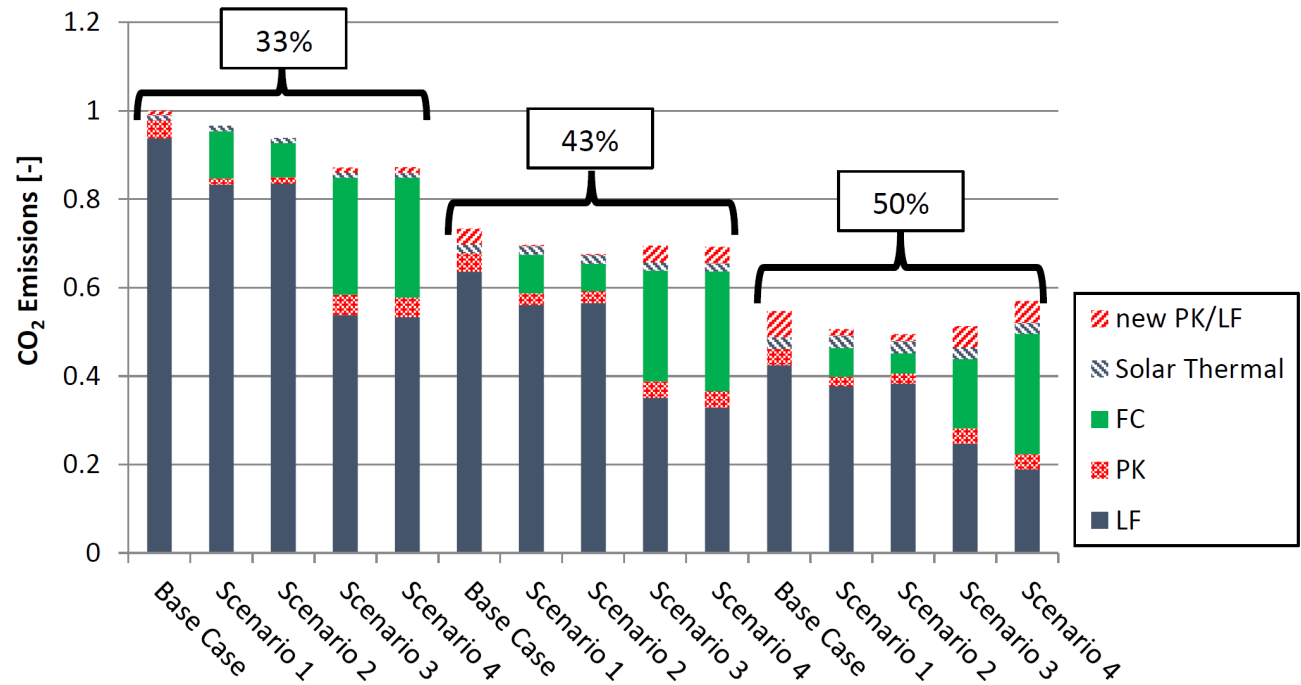
How it works

- Redundant, modular architecture provides highly reliable power
- System architecture replaces large and expensive backup generators and UPS components

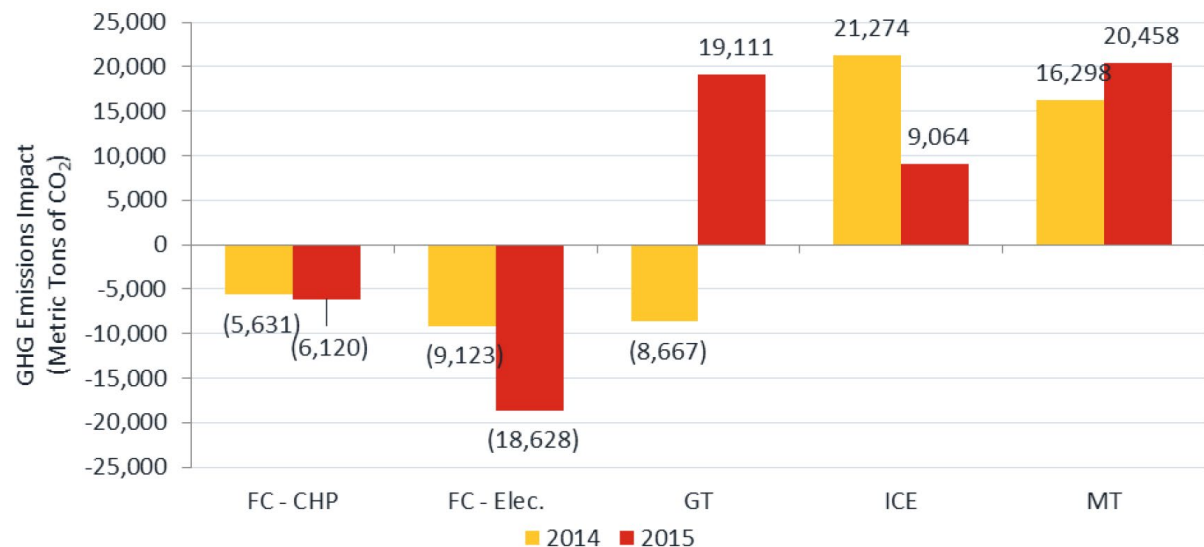


Fuel Cells for Decarbonization

UC Irvine full
grid simulations

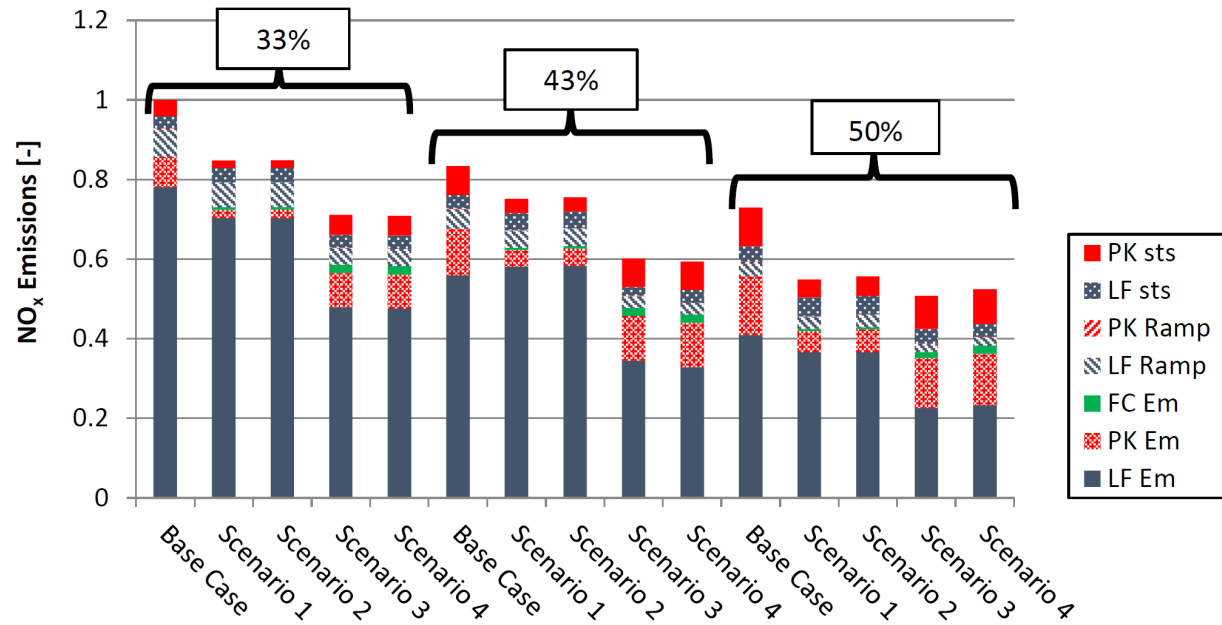


SGIP FC
fleet data

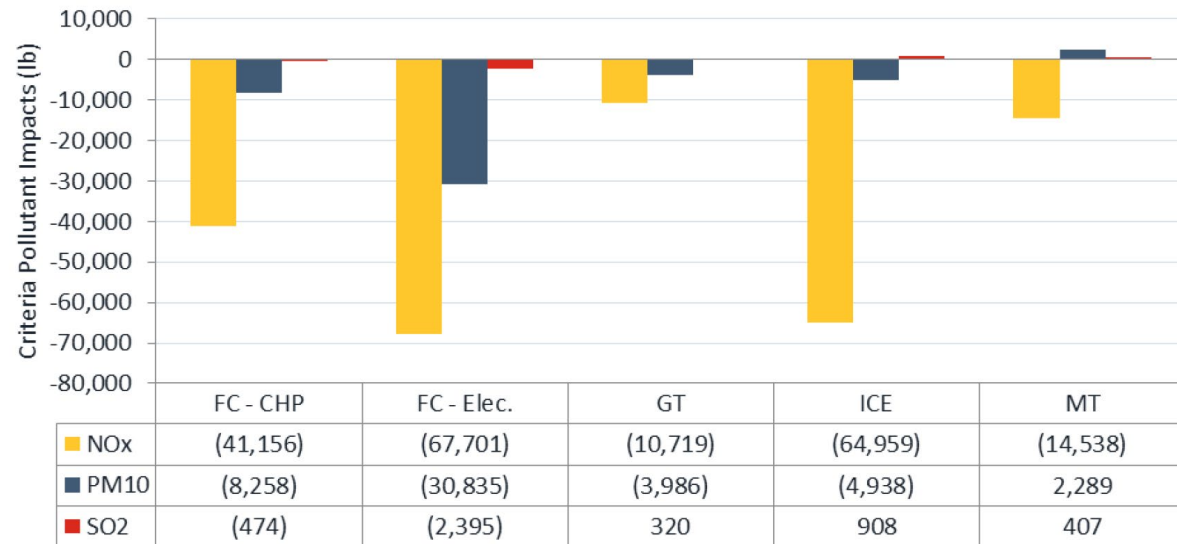


Stationary Fuel Cells Reduce Pollutants

UC Irvine full
grid simulations

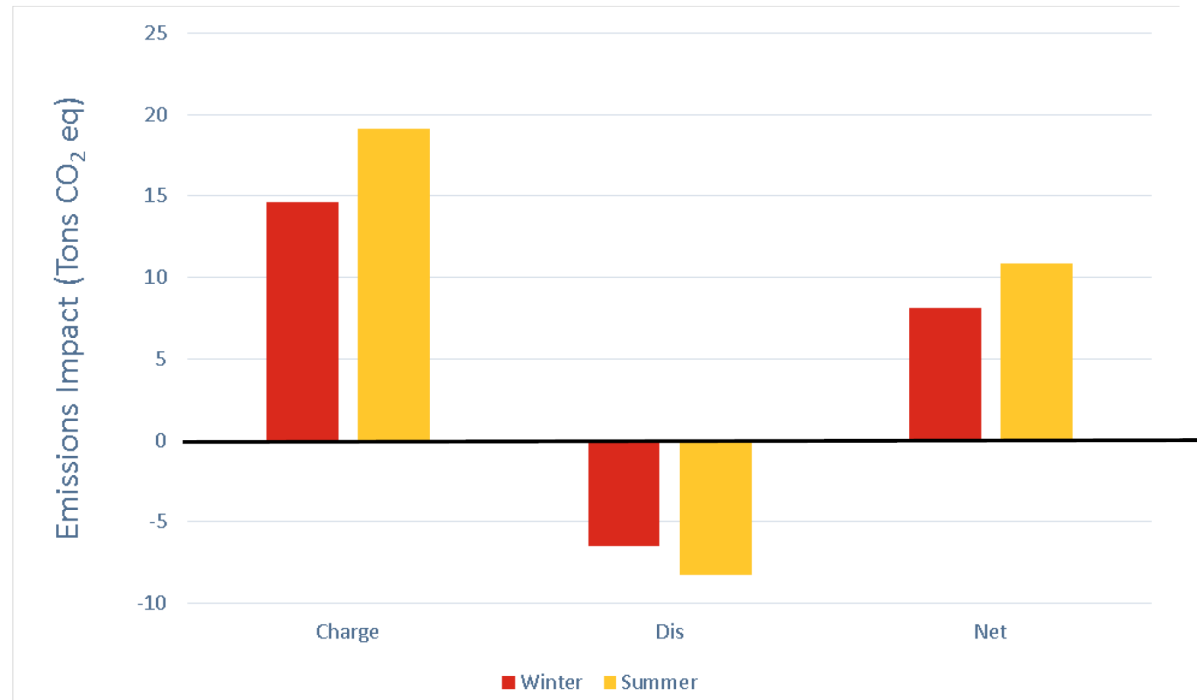


SGIP fuel cell
fleet data

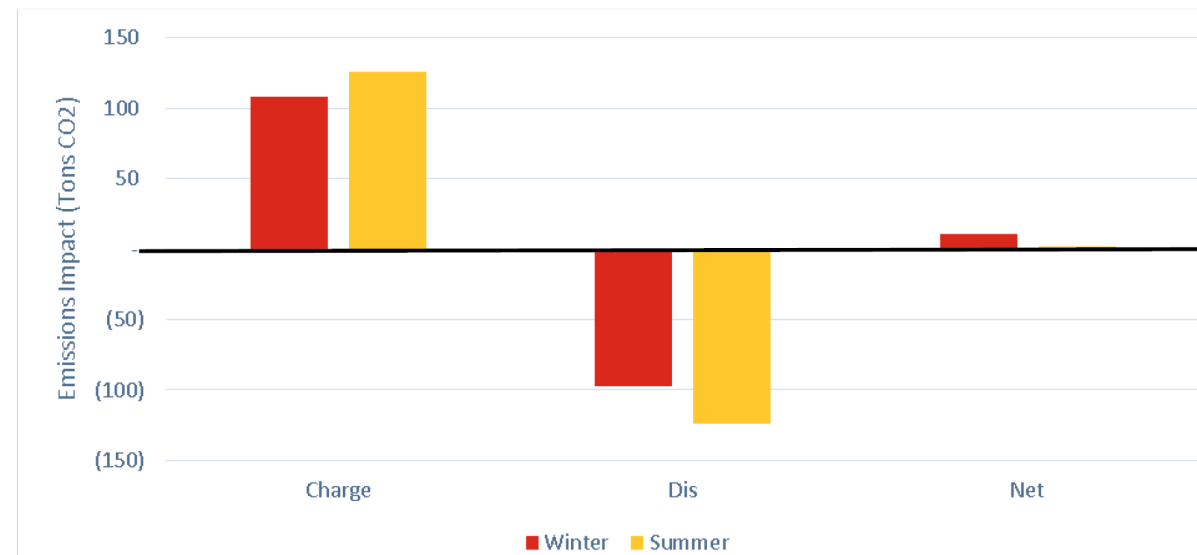


Poor Battery Dispatch & RTE Increases Emissions

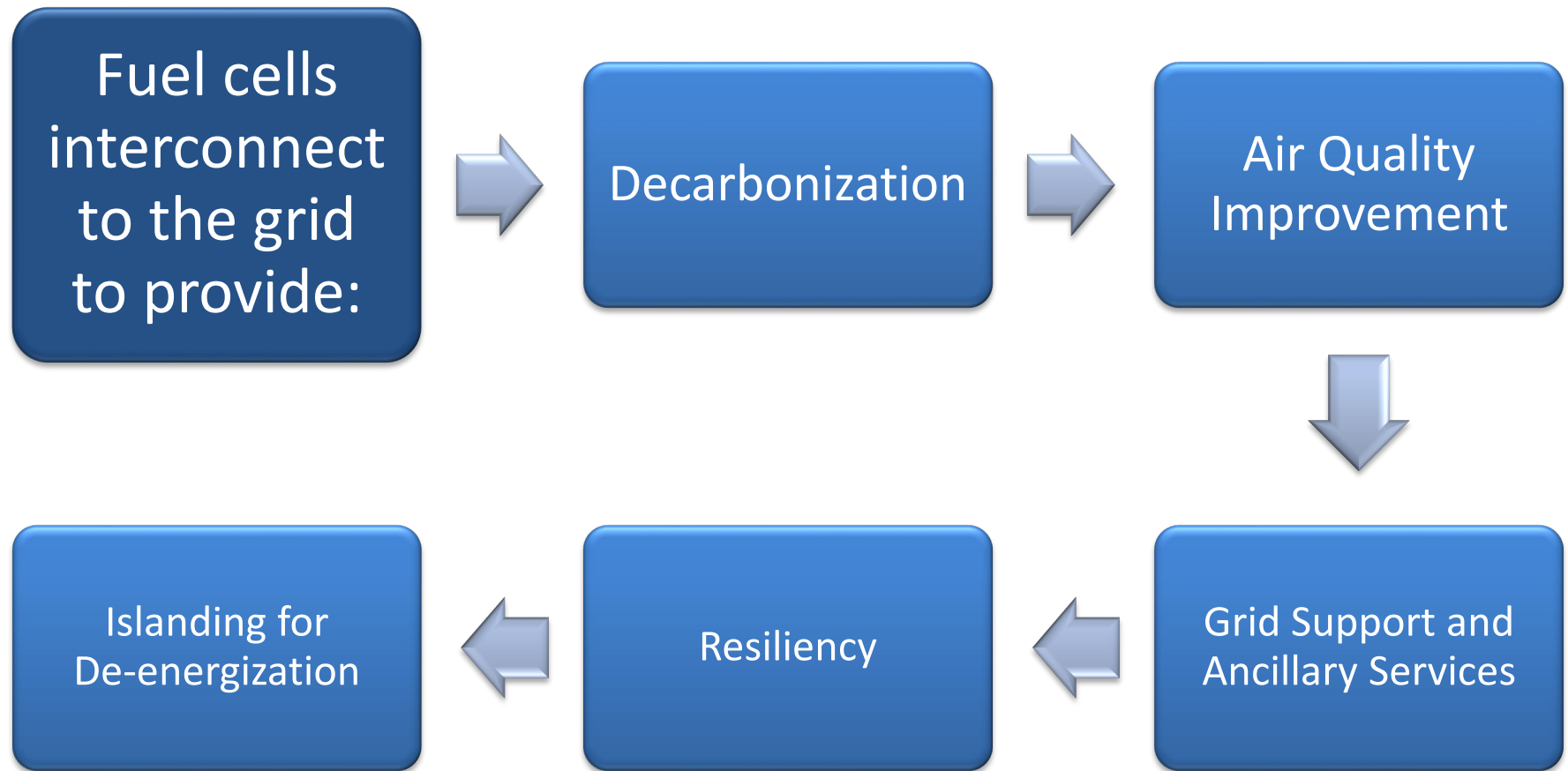
SGIP Battery
fleet data
(Non-PBI)



SGIP Battery
fleet data
(PBI)



Fuel Cells Achieve California's Energy & Climate Goals



Fuel Cells for Resiliency and Decarbonization in California

April 1, 2019

THANK YOU!



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Fuel Cell Collaborative**

