Fuel Cell Microgrids

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March 2018

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Goals

- Fuel Cell CHP Technology
- Technical, Operational, and Commercial Benefits in Microgrids

Fuel Cells - What are they?

- Generate electricity, and sometimes usable waste heat, by virtue of an electrochemical reaction

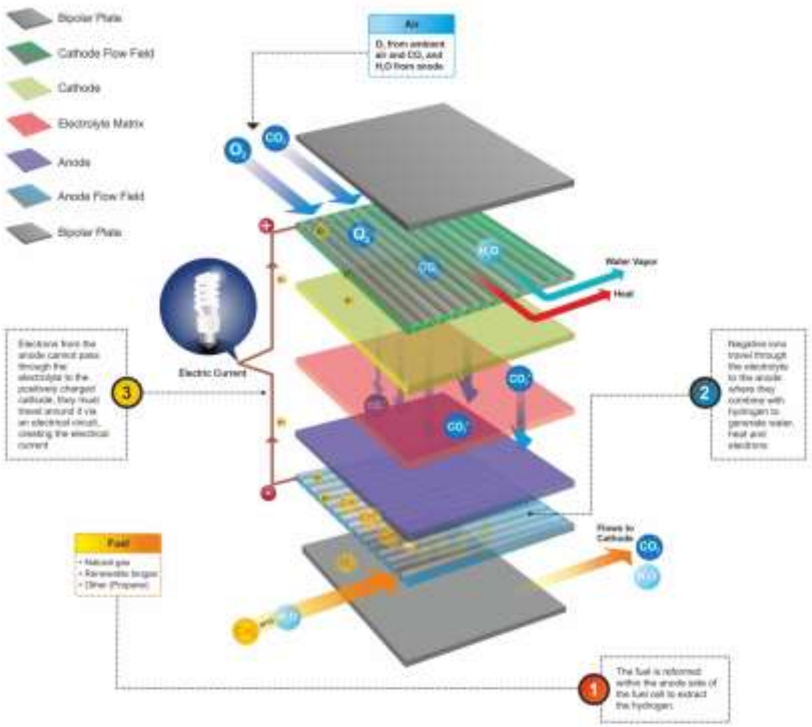
- No combustion, no criteria pollutant emissions (NOx, SOx, PM10)

- More efficient than competing baseload technologies, produce lower CO_2 emissions.

How a Fuel Cell Works

Electrochemical Conversion of Fuel to Electricity

- Consists of two electrodes—a negative electrode (or anode) and a positive electrode (or cathode)—sandwiched around an electrolyte
- Fuel and water is fed to the anode and air is fed to the cathode
- A catalyst at the anode separates hydrogen molecules into protons and electrons, creating a flow of electricity between cathode and anode
- The chemical reaction also produces water and heat



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Fuel Cell Configuration

Individual fuel cell component

400 components are used to build one 350 kW fuel cell stack

4 stacks are combined to build a 1.4 MW plant

The stacks are enclosed, creating the fuel cell module

Two modules are used for a 2.8 MW power plant

Fitting the Application

	MW - Class	Sub-MW-Class	
Technology	Carbonate	Phosphoric Acid	Solid Oxide
System Size Range	1.4 MW - 3.7 MW	400 kW	200 kW
Typical Application	Utilities, campuses, industrial - baseload	Commercial buildings - baseload	Commercial buildings - baseload
Fuel	Natural gas, Biogas, others	Natural gas	Natural gas
Advantages	High efficiency, scalable, fuel flexible & CHP	CHP	High Efficiency
Electricial Efficiency	47-60%	40% - 42%	50% - 60%
Combined Heat & Power (CHP)	Steam, hot water, chilling	Hot water, chilling	Depends on technology used

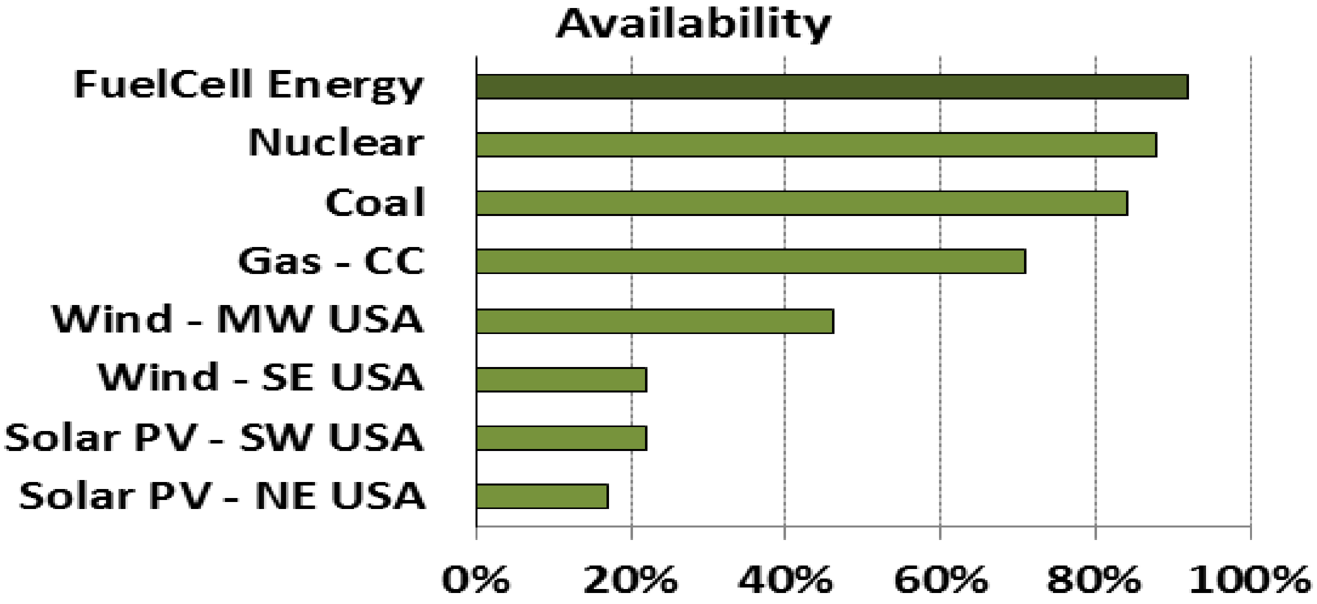
Fuel Cell CHP Plant

Microgrids

Need	Fuel Cell Provides
Reliability	High Availability and Resiliency
Savings	Electricity Savings Available in Major Markets
Sustainability	Criteria Pollutant and GHG Emissions Savings

Availability

High fuel cell plant availability



Source: FCE & NREL

Case Study – UC San Diego

- Grid-connected 2.8 MW fuel cell powered by Directed Biogas providing electricity and absorption chilling to campus grid

<u>Benefits</u>

- Cost savings during normal operations
- Microgrid satisfies 90% of campus electric needs
- Carbon neutral by utilizing directed biogas

“A fuel cell powered by directed biogas is the cornerstone of the micro-grid operation”

SYMPHONY OF THE MICROGRID AT AN URBAN UNIVERSITY

Case Study – University of Bridgeport

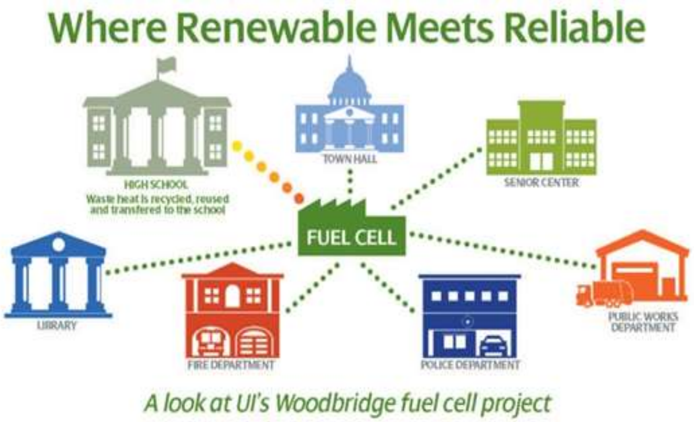
Project Overview

- 1.4 MW combined heat & power fuel cell power plant
- Supplies 80% of campus power needs
- Waste heat converted to hot water and supplied to three locations on campus
- Connecticut Microgrid Program Award

Benefits

- Cost savings during normal operations
- In a grid outage, power to critical facilities – shelter ~2700 persons, security, dining
- Renewable Energy Research Lab – “practice what we teach”
- Emissions reductions:
  7,000 tons CO_2, 64 tons SO_x, 28 tons NO_x

Case Study – Town of Woodbridge, CT



Project Overview

- 2.2 MW combined heat & power fuel cell power plant
- Power to UI grid during normal operation
- Supplies 100% of Town microgrid power needs during grid outage
- Heat supplied to Amity High School
- Connecticut Microgrid Program Award

Benefits

- Helps UI achieve its Class I RPS goals
- In a grid outage, power to critical facilities – police, fire, community services
- Savings to Amity High School ~ $100K per year from avoided natural gas
- Enabled upgrade to local gas grid delivery infrastructure

Case Study - PFIZER

Project Overview

- Grid-connected 5.6 MW fuel cell powered by Natural Gas
- Provides electricity and steam to Pfizer Groton campus
- Seamless grid independent capability
- Private, Critical Facility Microgrid

Benefits

- Closes electrical generation gap with a more reliable source than the commercial grid – makes site independent year round
- PPA structure with no up-front capital cost, delivers energy cost savings to Pfizer
- Enhances site sustainability profile (green energy source)
- Clean profile reduces permitting hurdles

"The self-reliance this plant affords us provides that stability and reliability of operation that we need"
Michael Lallier, Site Operations Manager, Pfizer

The Future Is . . .

- BRIGHT: Feb – 2018: 30% ITC Extended
  - Previously left out of 2015 tax credit extension for wind and solar

- GROWING: Regional Incentives
  - NYSERDA, LIPA, NJ CEP

- FUTURISTIC: Microgrid Opportunities
  - NJ TC DER
  - NY Prize

- NECESSARY: Advanced Technology
  - Carbon Capture
  - Hydrogen Production

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Backup

Grid Independent Capability

Fuel cells provide dependable, clean electricity and heat for microgrids, either alone or in parallel with other generation sources

Load Leveler operation profile: microgrid established in ~30 seconds

Grid Connected mode

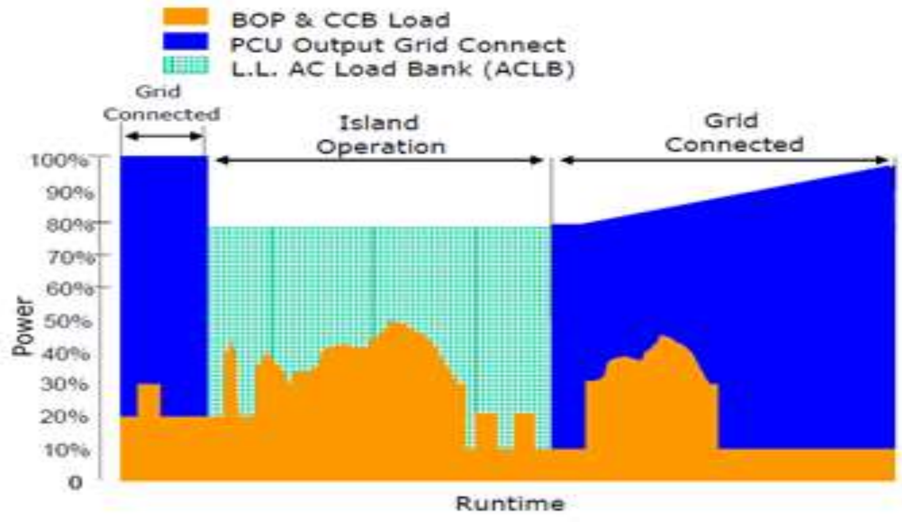
In normal operation the fuel cell synchronizes to local utility grid and offsets part or all of the load demand of the facility, reducing power needed from the utility

Microgrid mode

After a grid outage, facility loads see a brief interruption, and are then reconnected in a controlled manner to the fuel cell and other on-site sources

Critical Supply mode

Upon grid outage, disconnects from the grid and enters standby mode. Seamless backup power available to hard-wired customer critical loads up to 85% of fuel cell output



Schematic of the Load Leveler in Operation

Common Applications - Fuel