FuelCell Energy

Ultra-Clean, Efficient, Reliable Power

CHP Fuel Cells for Healthcare

*Presentation for **IDEA Annual Conference, St. Paul MN***

June 22, 2016

Ultra-Clean | Efficient | Reliable Power

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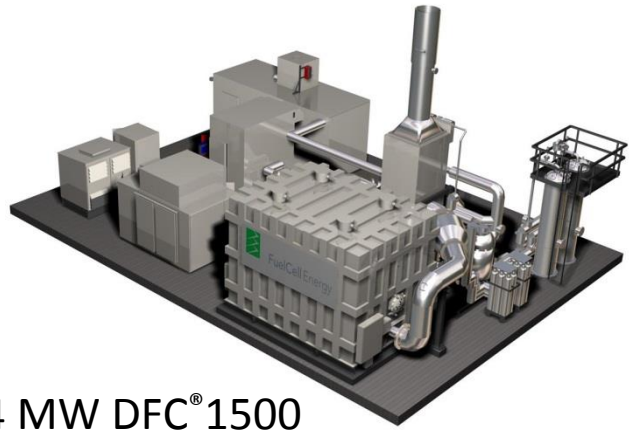
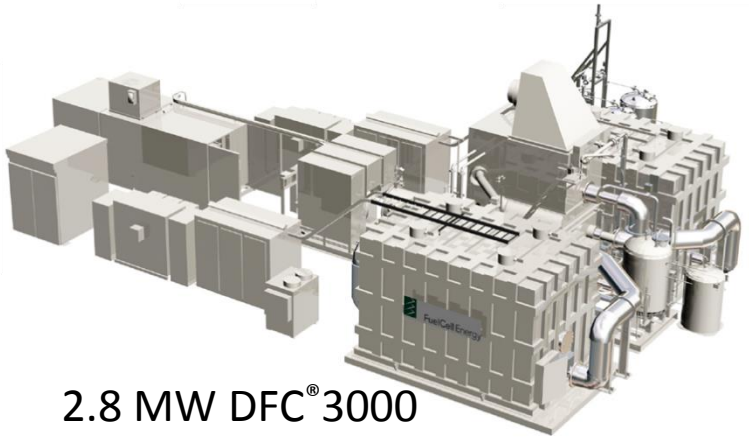
Fuel Cell Combined Heat & Power

The benefits from installing a fuel cell at a hospital include:

- **Cost Savings** – $200K per year or higher
- **Price Hedge** – known costs to protect against future increases in grid power
- **Improved Resiliency** – fully grid-independent micro-grid operation
- **Environmentally Friendly** – zero pollutant emissions, very low CO2 footprint
- **Fuel Flexible** – natural gas, propane, bio gas (anaerobic digester gas)
- **No Up-front Expense** – PPA structure requires payment only for kWh received



1.4 MW DFC®1500



2.8 MW DFC®3000

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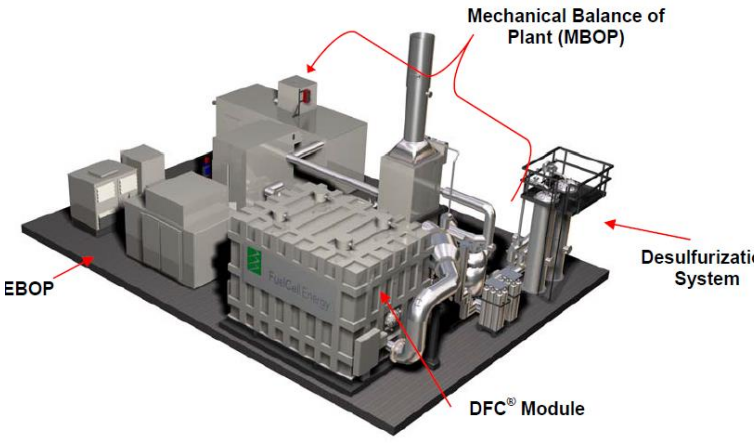
DFC®1500 Fuel Cell Power Plant

The DFC®1500 stationary fuel cell power plant from FuelCell Energy provides high-quality, Ultra-Clean electrical power with 47% efficiency, and high quality exhaust heat suitable for hot water, steam, or absorption chilling applications, around the clock. Designed for commercial and industrial applications, the system offers easy transport, quiet and reliable operation, and simple site planning and regulatory approval. The DFC1500 is ideal for wastewater treatment plants, manufacturing, food and beverage processing, universities and office campuses.

Gross Power Output	
Power @ Plant Rating	1,400 kW
Standard Output AC voltage	480 V
Standard Frequency	60 Hz
Optional Output AC Voltages	By Request
Optional Output Frequency	50 Hz
Efficiency	
LHV	47 +/- 2 %

Available Heat	
Exhaust Temperature	700 +/- 50 °F
Exhaust Flow	18,300 lb/h
Allowable Backpressure	5 iwc
Heat Energy Available for Recovery	
(to 250 °F)	2,216,000 Btu/h
(to 120 °F)	3,730,000 Btu/h

Pollutant Emissions	
NOx	0.01 lb/MWh
SOx	0.0001 lb/MWh
PM10	0.00002 lb/MWh
Greenhouse Gas Emissions	
CO_2	980 lb/MWh
CO_2 (with waste heat recovery)	520-680 lb/MWh



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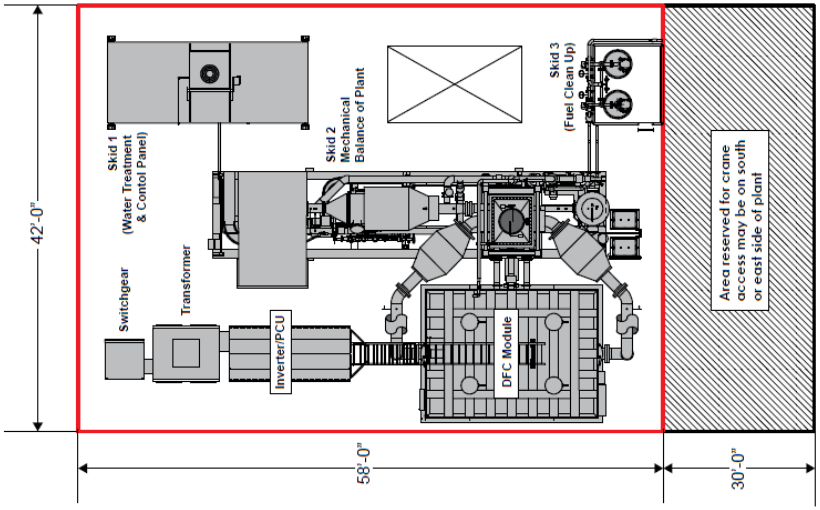

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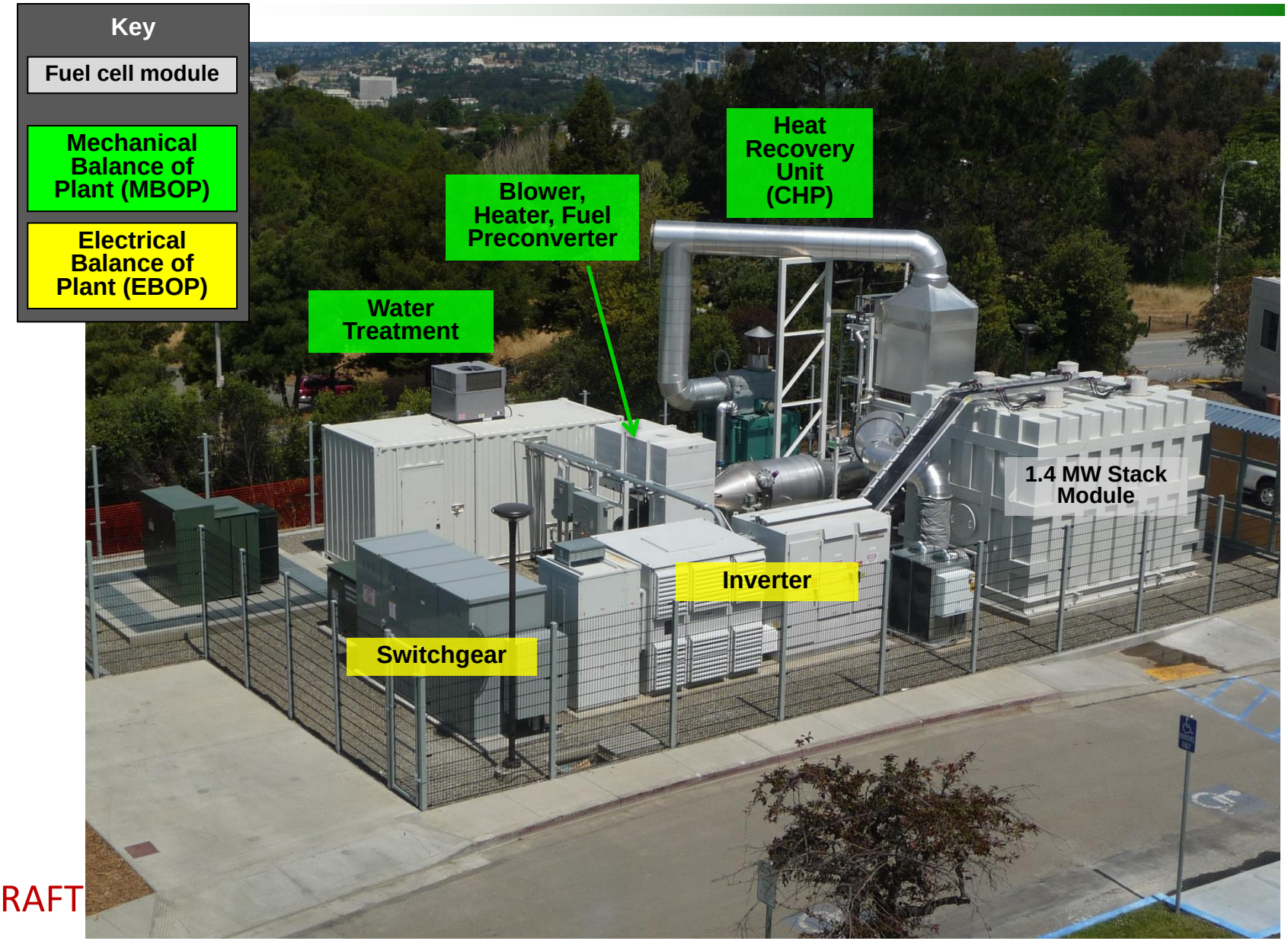
Direct FuelCell® Power Plant



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Grid-Independent Capability

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

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

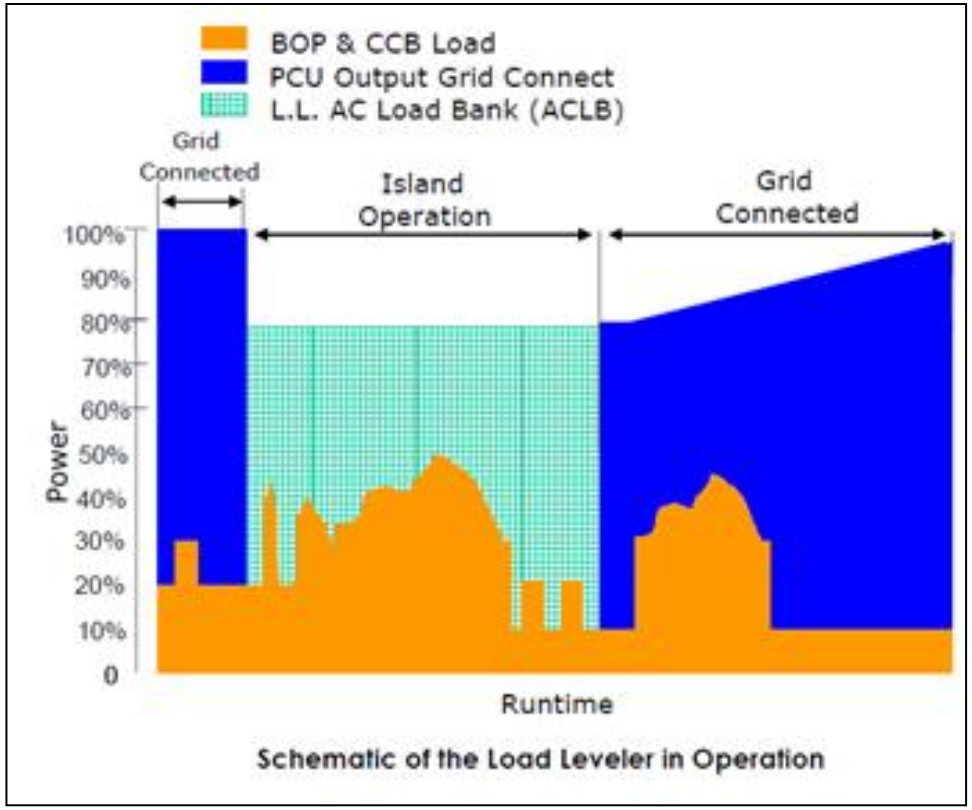
Microgrid mode

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

Load Leveler operation profile: microgrid established in ~30 seconds



Schematic of the Load Leveler in Operation

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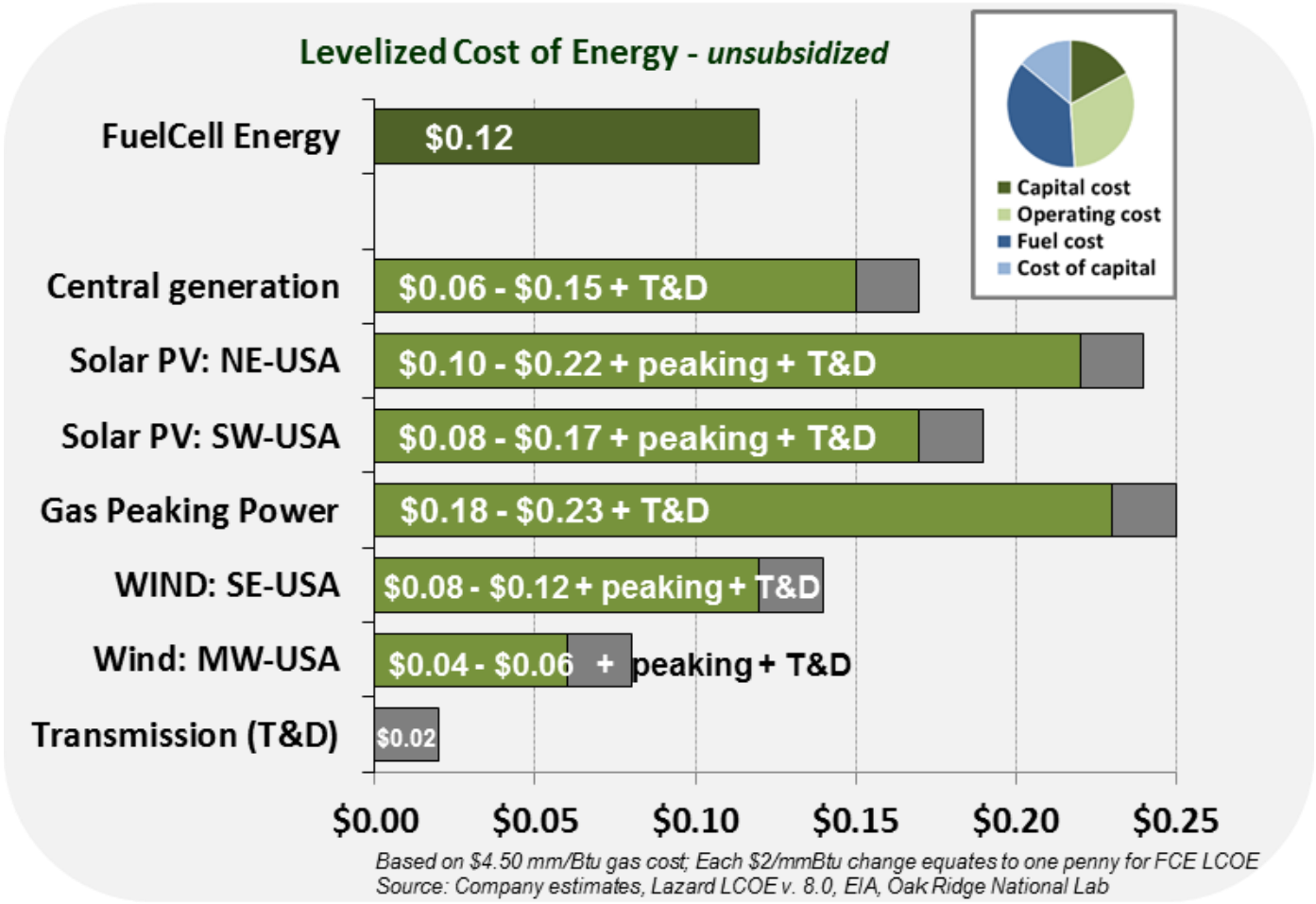
LCOE



Renewable Energy Credits (RECs), Federal Investment Tax Credit (ITC) and Heat Use enable LCOE ~ $0.09/kWh

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Hospital Case Study

Hartford Hospital

Hartford Hospital

Challenge

- Increase efficiency, reduce costs, and stabilize operating budgets in a volatile energy market
- Electricity and heat to the hospital
- Capable of islanded operation – supplying power to the hospital even in the event of a grid disruption.

Solution

- Fuel cell provides 1.4 MW electricity meeting ~50% of the hospital's power
- Electricity and steam sold to the hospital via an Energy Purchase Agreement
- Excess steam sent to urban district heating system serving a network of steam users

1.4 MW fuel cell plant operating on natural gas providing electricity and heat to Connecticut's 2nd largest hospital

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Hospital Case Study

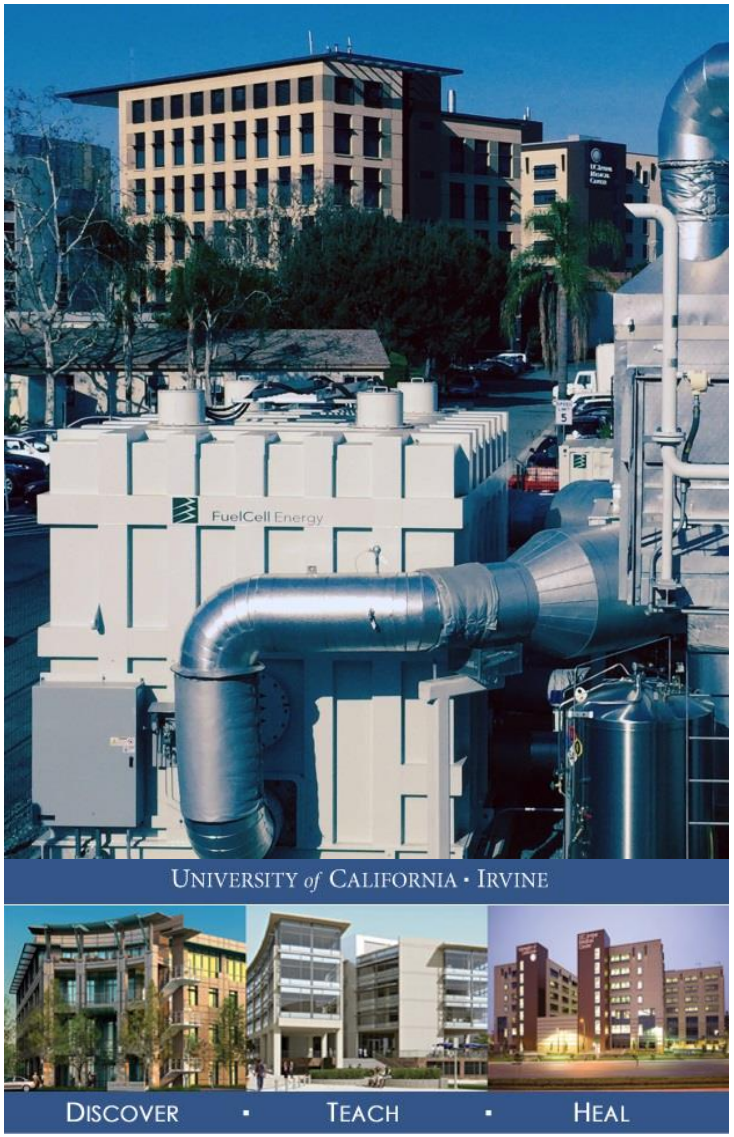
UC Irvine Medical Center

Challenge

- Control energy costs and reduce price volatility in a high cost energy market
- Ability to permit on-site energy in South Coast Air Quality Management District
- Need for greenhouse gas reduction as part of University of California system
- Compliance with CA OSHPD requirements

Solution

- 1.4 MW fuel cell incorporating absorption chiller recovering 1.6 MMBtu/hour heat from fuel cell exhaust delivering 200 RT
- Turnkey DBO model under 20 year Power Purchase Agreement
- Full O&M including guarantees of performance built into PPA payment



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OSHPD Certification

Because the fuel cell is not providing backup power the permits needed from the California Office of Statewide Planning and Health Development (OSHPD) are minimal

Two OSHPD requirements for UCI Med Center:

- Chilling water tie in
  - OSHPD Design approval obtained
  - OSHPD Inspection complete
- Optic signal from DFC power plant to SCE gear
  - OSHPD Design-approved routing plan complete
  - OSHPD Inspection complete

OSHPD waiver granted for the DFC power plant because:

- DFC power plant is not standby or emergency back up power and is not critical to hospital operations http://oshpd.ca.gov/FDD/Regulations/PINs/55.pdf
- The operation of the DFC power plant and related heat recovery equipment, and/or lack thereof, will be completely invisible to the operation of the hospital which will continue to operate in its existing conditions regardless of the DFC power plant operating status.

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Hospital Case Study

UC San Diego Scripps Medical Center

BioCycle energy

92% SELF-GENERATED ENERGY

SYMPHONY OF THE MICROGRID AT AN URBAN UNIVERSITY

As of the fourth quarter of 2013, nearly 100 percent of all architecturally suitable campus building rooftops at UCSD are photovoltaic-equipped.

The University of California San Diego's microgrid produces 92 percent of its annual electricity load and 95 percent of its

megawatt microgrid, however, is more than just a backup in case of disaster. It self-generates 92 percent of UCSD's annual electricity load and 95 percent of its heating and cooling load, which is no mean feat, as UCSD has 11.6 million square feet of buildings. Six million of the total square feet have been added in the last 10 years, an area equal to 60 percent of the Pentagon, Washom adds.

Washom likens the operation of the university's state-of-the-art microgrid to a symphony, where many instruments seamlessly integrate a [illegible] into a beautiful serenade. Operators each must know how and when to cede performance to the most optimally placed instrument. "Within microgrid development, gas turbines or fuel cells are an essential cornerstone in order to firm up the generation reliability," he explains. "And of the two fuel choices for those, natural

says Byron Washom, Director of Strategic Energy for UCSD's campus. This 42-

BioCycle

June 2014

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

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Project Overview

- Grid-connected 2.8 MW fuel cell powered by Directed Biogas
- Runs in parallel with 30 MW gas turbine, PV, and battery storage
- Installed adjacent to the Medical Center, providing electricity and absorption chilling to UCSD campus

Benefits

- Cost savings during normal operations
- Microgrid satisfies 90% of campus electric needs
- Carbon neutral by utilizing directed biogas
- PPA delivers sustainability, resiliency & cost savings with no up-front expense

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Prison Case Study

Challenge

- California DGS desired to reduce Carbon footprint at State facilities
- Increasing and unpredictable energy costs
- Certainty of future savings for energy contracts
- Maintain high security and reliability

Solution

- Fuel cell provides 1.4 MW electricity in parallel with Solar and Battery Storage
- Exhaust heat recovery supplies steam to Facility
- Full grid-independent capability
- Originally installed first-gen plant in 2004, renewed under PPA structure in 2015

1.4 MW fuel cell plant operating on natural gas providing electricity and heat to Santa Rita Jail, County of Alameda

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University Case Study

University of Bridgeport

Project Overview

- 1.4 MW combined heat & power fuel cell power plant
- Supplies 80% of campus power needs
- First fuel cell project placed into a yieldCo

Benefits

- Cost savings during normal operations
- In a grid outage, power to critical facilities – shelter, security, dining
- Renewable Energy Research Lab – "practice what we teach"
- Emissions reductions:
  - 7,000 tons CO2, 64 tons SOx, 28 tons NOx

"Sustainable and affordable energy is an increasingly important component of the new energy mix at the University of Bridgeport.
-Neil Albert Salonen, President, University of Bridgeport

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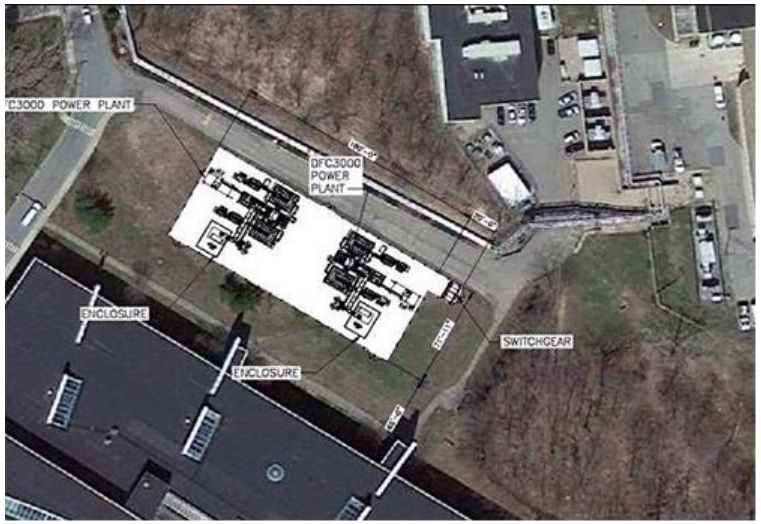
Industrial Case Study

Pfizer R&D Center, Groton CT

Grid-connected 5.6 MW fuel cell powered by Natural Gas providing electricity and steam to Pfizer Groton campus

- Closes electrical generation gap with a more reliable source than the commercial grid – makes site independent year round
- Reduces commercial power to a back-up role
- Enhances site sustainability profile (green energy source)
- Positions power and steam generation on the North Campus (closer to some end-users)
- Captures a base load of “free” steam generation from the fuel cell for use on the North Campus
- Improves the site business continuity profile
- PPA structure with no up-front capital cost, financing arranged by FCE; Pfizer provides NG



Pfizer Groton installation site

5.6 MW fuel cell installation in South Korea

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15 Megawatts of Ultra-clean, Quiet & Reliable Power

- Five FuelCell Energy power plants generating continuous power in a virtually pollutant-free manner
- Enhances grid resiliency, supplying electricity to three substations powering the City
- Dominion is the project owner, diversifying its power generation portfolio with fuel cells
- FuelCell Energy operates and maintains the fuel cell park under a long term service agreement
- City of Bridgeport receives property tax revenue as location was formerly a brownfield site
- State of Connecticut benefits from environmentally-friendly power generation and ‘green’ job creation/retention

Dominion

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CLEAN ENERGY
FINANCE AND INVESTMENT AUTHORITY

EVERSOURCE ENERGY

Take-Aways

- Fuel Cell CHP systems offer many benefits to Hospitals: Cost Savings, GHG reduction, and improved Resiliency
- Financed by private capital with no up-front cost to the Hospital
- Turnkey EPC offering minimizes disruption to Hospital staff
- OSHPD waivers are granted because DFC power plant is not standby or emergency back up power, and is not critical to hospital operations
- 300-bed hospitals typically have enough electric load and thermal requirements to utilize all output from 1.4 MW plant
- Utility grid costs around $0.12/kWh or higher and available space are key
- Fuel cells provide an excellent generation backbone for microgrids: clean, quiet, efficient and financeable

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Thank you

Ben Toby | Vice President, Sales
Direct: 203.825.6114 | Cell: 203.482.0637 | btoby@fce.com

FuelCell Energy, Inc. | 3 Great Pasture Rd | Danbury, CT 06810
www.fuelcellenergy.com

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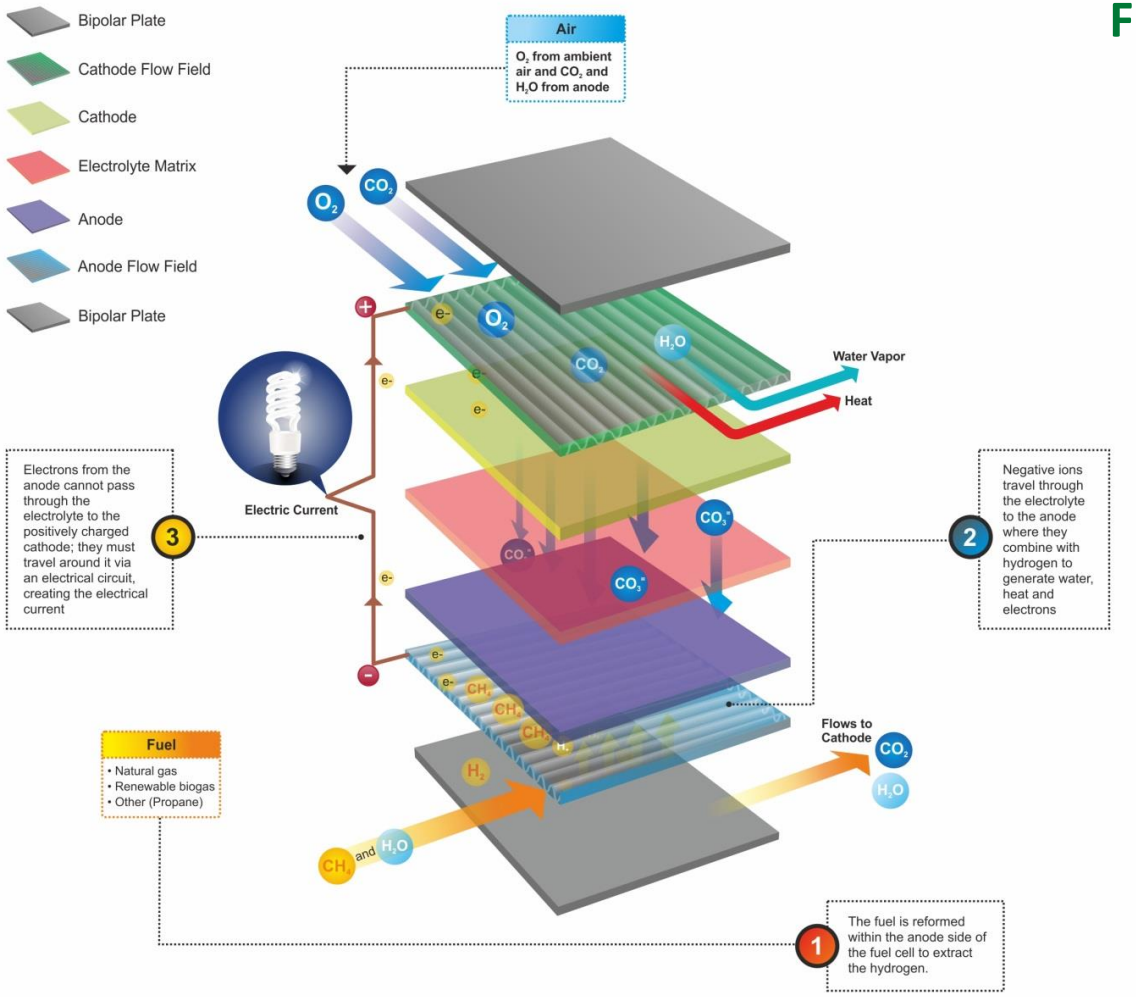
How the Direct FuelCell® Works



Electrochemical Conversion of Fuel to Electricity

- Highest electrical efficiency for its size class
  - Combined heat and power (CHP)
- Ultra-clean
  - No combustion
  - Negligible NO_x (*smog*), SO_x *(acid rain),* PM^{10} *(asthma)*
- Continuous power
- Easy to site
  - Low emissions, quiet, only modest space needs
- Fuel flexible
  - Clean natural gas
  - Renewable biogas
  - Directed biogas
  - Propane

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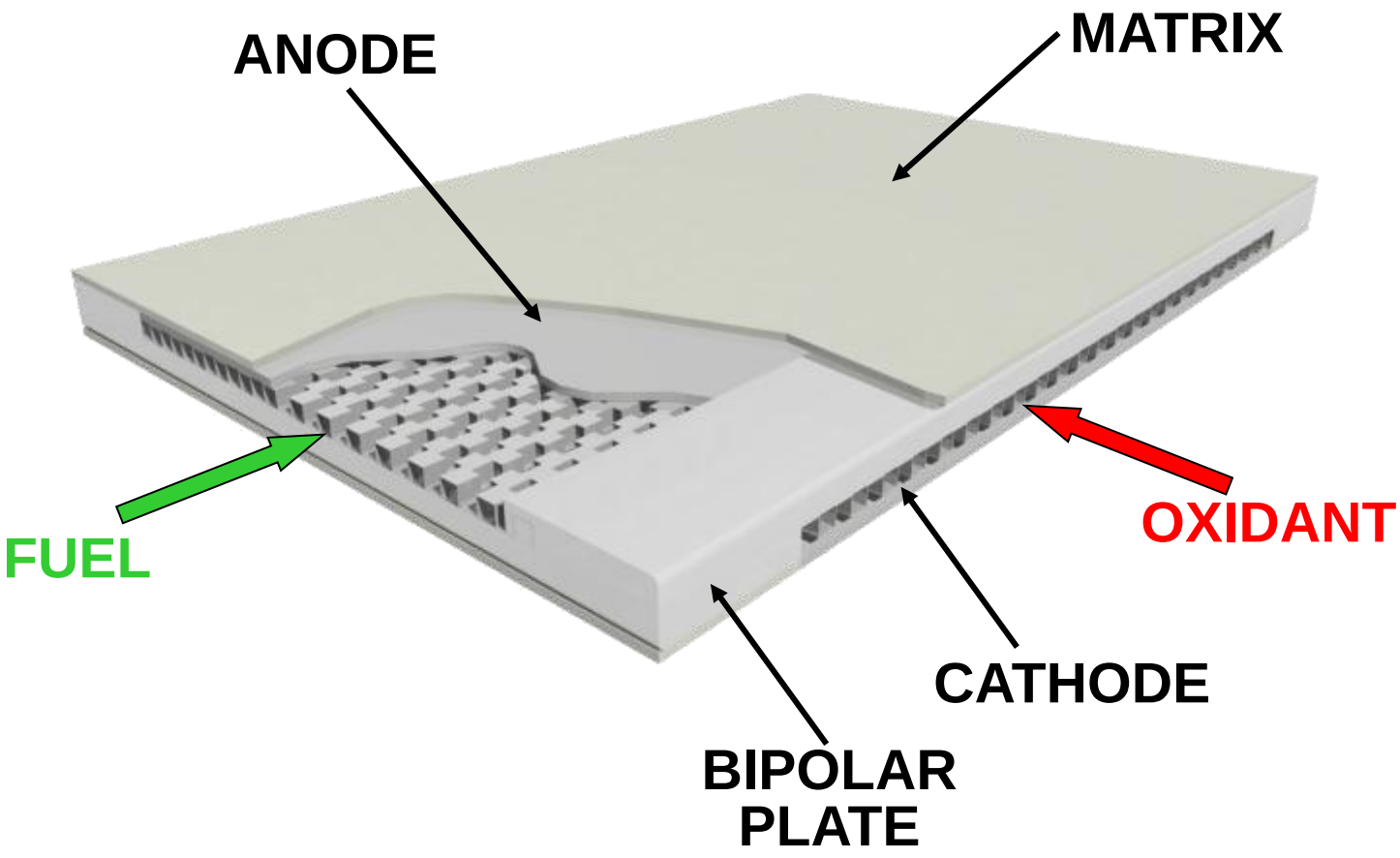
Fuel Cell Configuration



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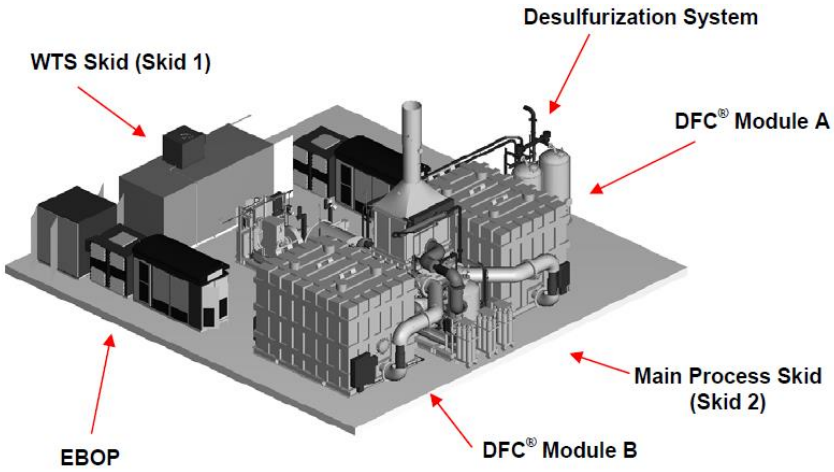
DFC®3000 Fuel Cell Power Plant

FuelCell Energy's DFC3000™ system is the largest of the Direct FuelCell® (DFC®) power plant fleet, capable of providing high-quality baseload power with 47% electric power generation efficiency around-the-clock. Scalable for Multi-Megawatt Fuel Cell Parks, the system is especially suitable for applications with larger load requirements such as universities, manufacturing facilities, wastewater treatment plants, and utility/grid support.

Gross Power Output		**Available Heat**		**Pollutant Emissions**	
Power @ Plant Rating	2,800 kW	Exhaust Temperature	700 +/- 50 °F	NOx	0.01 lb/MWh
Standard Output AC voltage	13,800 V	Exhaust Flow	36,600 lb/h	SOx	0.0001 lb/MWh
Standard Frequency	60 Hz	Allowable Backpressure	5 iwc	PM10	0.00002 lb/MWh
Optional Output AC Voltages	By Request				
Optional Output Frequency	50 Hz	Heat Energy Available for Recovery		**Greenhouse Gas Emissions**	
		(to 250 °F)	4,433,000 Btu/h	CO_2	980 lb/MWh
Efficiency		(to 120 °F)	7,460,000 Btu/h	CO_2 (with waste heat recovery)	520-680 lb/MWh
LHV	47 +/- 2 %				



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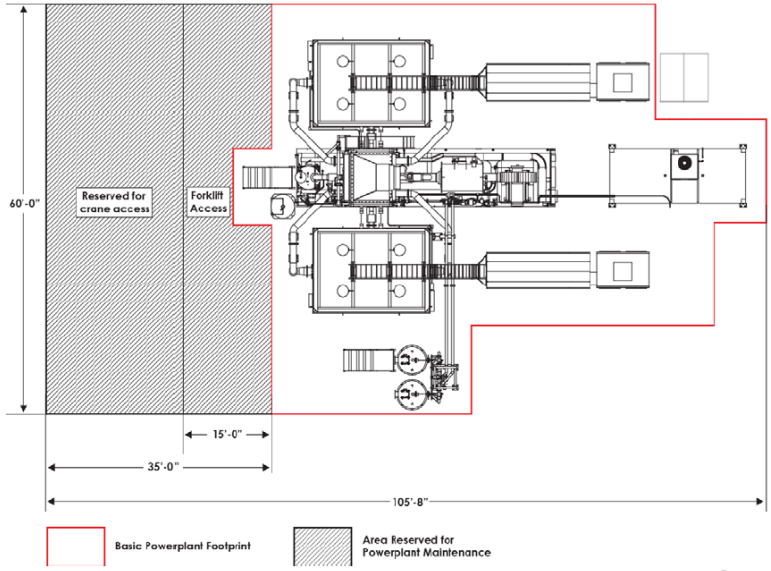

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