FuelCell Energy

Ultra-Clean, Efficient, Reliable Power

University Microgrids Powered by Fuel Cells

Achieving Sustainability and Security while Lowering Costs: Case Studies from Connecticut and California

Presentation to IDEA Campus Energy 2015, Denver Colorado
Thursday February 12th, 2015 8:30 – 9:00 am Track 4C

Ultra-Clean | Efficient | Reliable Power

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Why Fuel Cells?

- Clean, Quiet & Efficient
- Energy Cost Savings
- Financeable, Low-Risk
- Improved Reliability & Resiliency

Power Source	Efficiency (%LHV)	NOx (lb/MWh)	SOx (lb/MWh)	PM^{10} (lb/MWh)	CO_2 (lb/MWh)
Average U.S. Grid	33%	3.43	7.9	0.19	1,408
Average U.S. Fossil Fuel Plant	36%	5.06	11.6	0.27	2,031
DFC® Fuel Cell on Nat Gas	47%	0.01	0.0001	0.00002	940
DFC® Fuel Cell on Nat Gas (CHP)	80%	0.006	0.00006	0.00001	550
DFC® Fuel Cell on Biogas (CHP)	80%	0.006	0.00006	0.00001	0

Source: The Regulatory Assistance Project report to NREL, October 15, 2002

Hartford Hospital, 1.4 MW

Cal State East Bay, 1.4 MW

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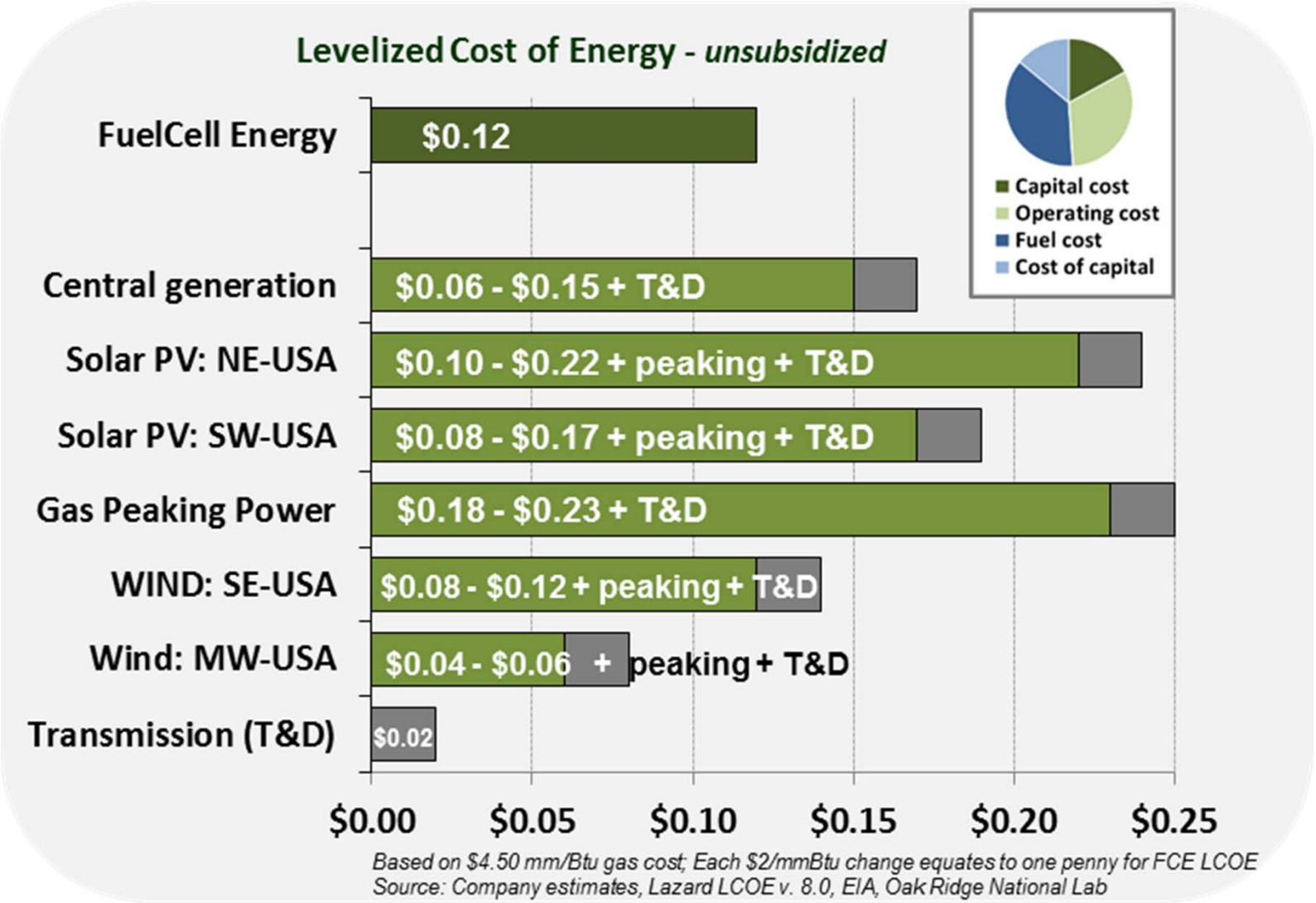
Energy Cost Savings



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University Installations

University of California, San Diego
2.8MW, in service since Dec. 2011

Cal State University, Northridge
1.0MW, in service since Dec. 2006

Cal State University, East Bay
1.4MW, in service since August 2011

San Francisco State University
1.4MW, in service since July 2011

Cal State University, San Bernardino
1.4MW, in service since July 2013

Central Connecticut State University
1.4MW, in service since Jan 2012

University of Bridgeport CT
1.4 MW, will enter service March 2015

UC Irvine Medical Center
1.4MW, will enter service mid-2015

12.2 MW at eight campuses

Cal State Northridge

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Project Financial Model

- Comprehensive Engineering, Procurement, and Construction services – leverages FCE strength and experience, lowers risk and distractions to Client
- PPA, Lease, Debt Financing
- PPA, Operating lease enable 30% ITC at Universities, Hospitals, Non-Profits
- $40M revolving fuel cell project finance fund with NRG
- Comprehensive Service Agreements with guarantees of fuel cell performance

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Dominion

No up-front capital, energy cost savings, low risk

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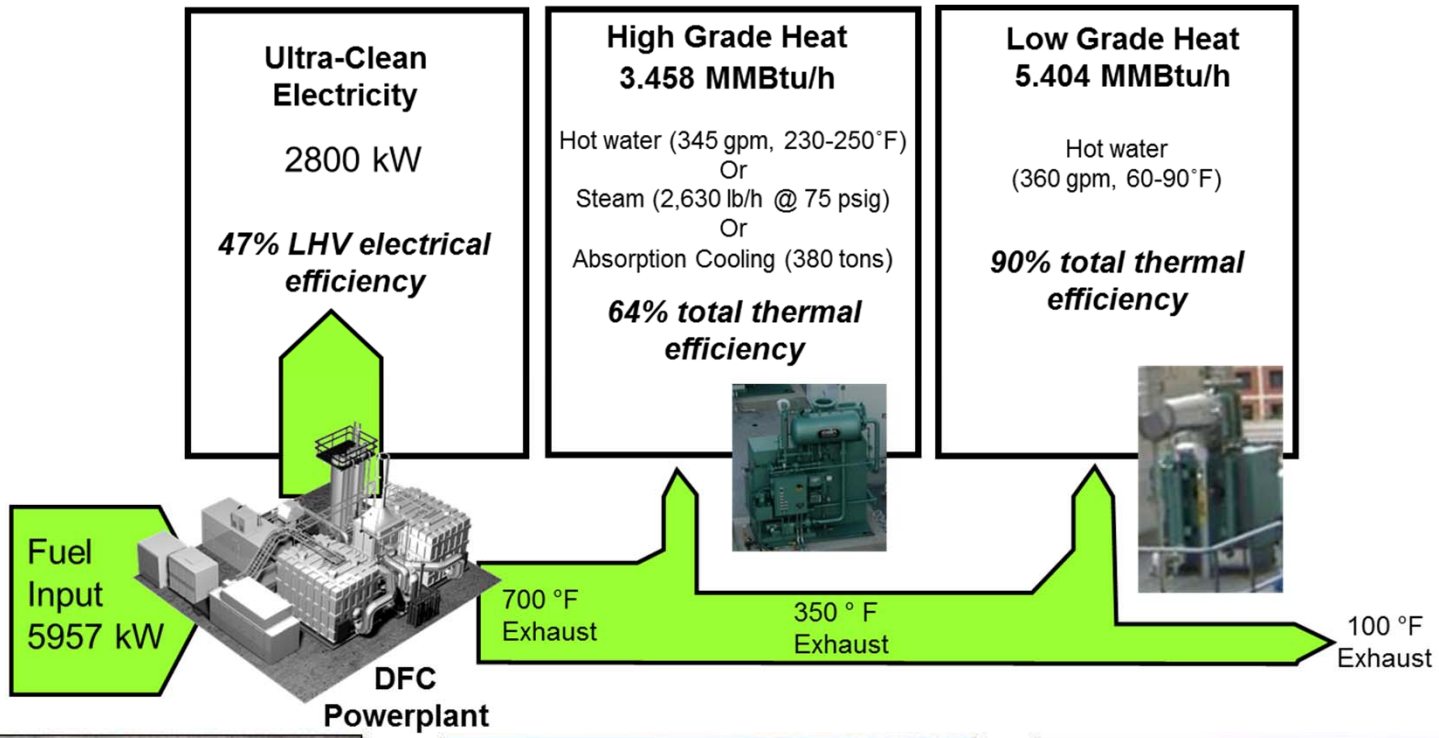
Combined Heat & Power (CHP)



300 kW Hot Water CHP for Onion Waste digester in California

1.4 MW Steam CHP for campus energy system at University in CT

2.8 MW Hot Water CHP Waste Water Digester Plant in California

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Microgrid Applications

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

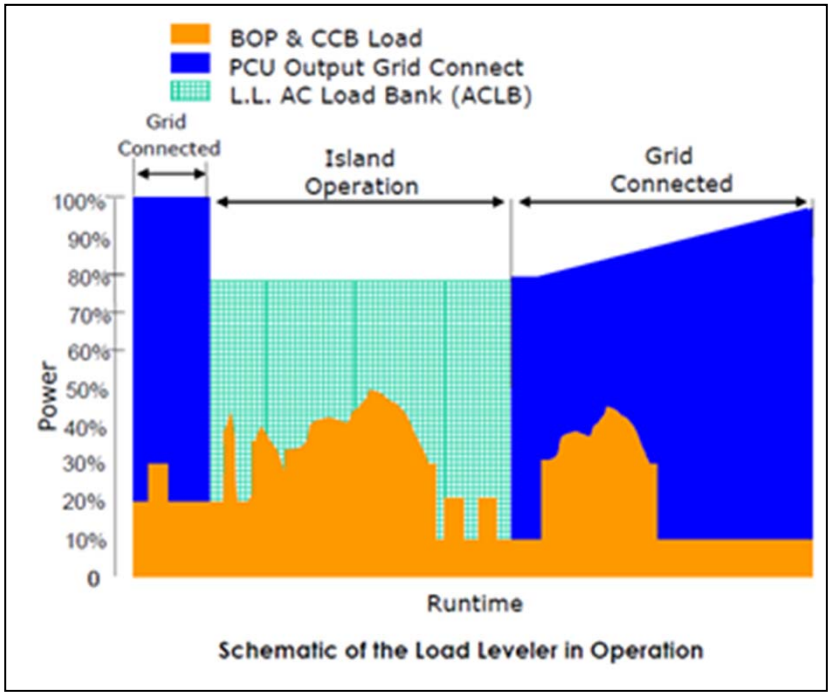
Grid Independent mode

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

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

Load Leveler operation profile: microgrid established in ~1 minute



Schematic of the Load Leveler in Operation

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CCSU Microgrid

Grid-connected 1.4 MW fuel cell delivering electricity and 125 psig steam to the campus energy loop

Benefits

- Power Purchase Agreement – no up-front capital expenditure by University
- Energy cost savings ~ $100K per year
- 3,000 tons per year CO_2 reduction supports sustainability goals
- Reliable power during prolonged grid outage

Features

- Fuel cell operates in parallel with two 1-MW gensets
- Two points of disconnect to CL&P grid
- External microgrid controller
- 3.4 MW powers campus dorms and critical facilities
- In operation since Q1 2013

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GREENWOOD ENERGY

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University of Bridgeport Microgrid

Grid-connected 1.4 MW fuel cell delivering electricity and high temp hot water to three campus dorms

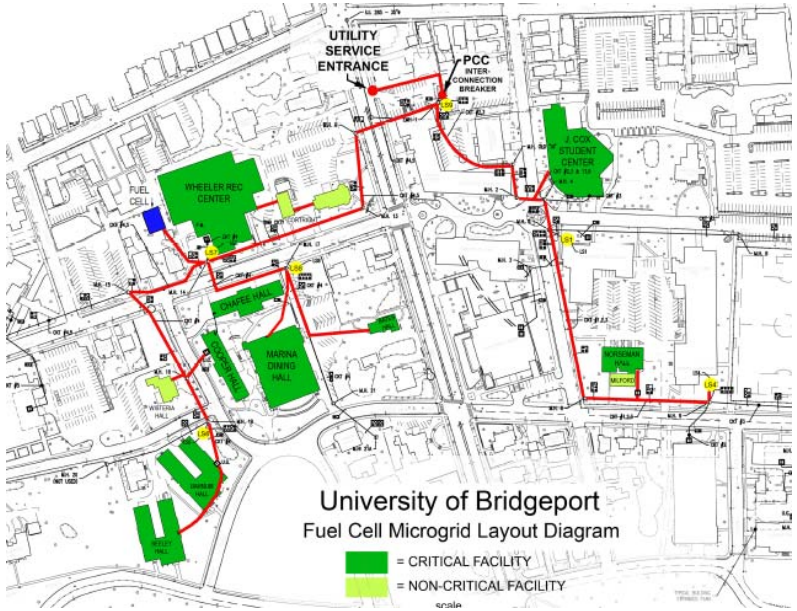
Benefits

- Fuel cell under PPA – no up-front capital
- ITC monetized, savings passed to UB
- Energy cost savings ~ $200K per year
- Reliable power during prolonged grid outage – refuge for UB students, City of Bridgeport, Sacred Heart and Fairfield University students, and Dept. of Homeland Security personnel

Features

- During outage, fuel cell is sole generating source for six critical facilities – dorms, dining facility, campus security
- Fully automated microgrid
- Will enter operation March 2015

$2.2M Grant awarded in Round 2 of CT DEEP Microgrid program (2014)



University of Bridgeport Microgrid

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UCSD Microgrid

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

Benefits

- Fuel cell under PPA – no up-front capital
- ITC monetized, savings passed to UCSD
- UC carbon neutrality by 2025
- Full 42 MW system saves $800K per month

Features

- 42 MW total from gas turbine, fuel cell, PV and energy storage – provides 92% of campus electric load and 95% of heating and cooling load
- Fuel cell operates at 68% overall efficiency
- Directed biogas from Point Loma wastewater treatment plant
- In operation since 2012

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 heating and cooling load. A fuel cell powered by directed biogas is a cornerstone of the operation.

Marsha W. Johnston

PERCHED on the wind-sculpted bluffs above the Pacific Ocean, the University of California San Diego (UCSD) is one of the world's leading research universities, with an average R&D budget of $1 billion in each of the last three years. Research includes over 50 years of investigating climate change at UCSD's Scripps Institution of Oceanography, making it no surprise that the university operates one of the world's most advanced, low emission microgrids.

"There is definitely a movement toward microgrids for communities, industries and military bases that are looking to increase three things: reliability, survivability and resiliency when natural or manmade disaster occurs," says Byron Washom, Director of Strategic Energy for UCSD's campus. This 42-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 must seamlessly integrate a multitude of notes into a beautiful serenade, and where 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

BioCycle JULY 2014

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Summary

- Significant experience worldwide, gaining momentum – expanding U.S. and overseas manufacturing
- CO_2 savings with NG fuel in CHP mode, even better with Biogas
- University campuses are a great technical fit: base load power need, robust heat loads, leaders in sustainability, and in need of continued operations during grid outages
- PPA and Lease financing are readily available, eliminating the need for up-front capital investment and enabling 30% ITC
- Attractive to students and faculty in the STEM and environmental communities

Demonstrating environmental leadership while saving costs and strengthening campus infrastructure

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Thank you!

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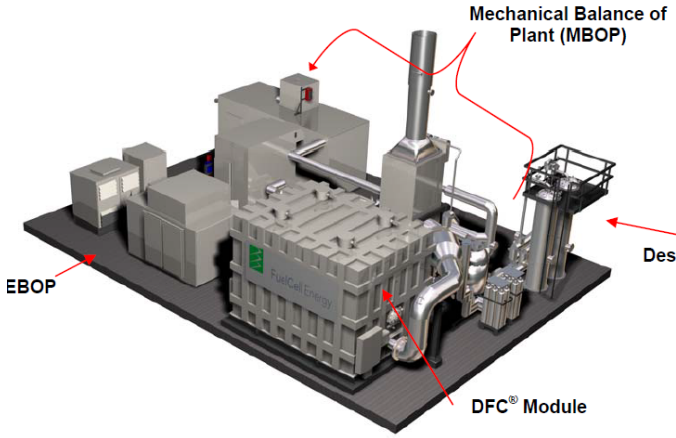
DFC®1500 Fuel Cell Power Plant

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		**Available Heat**		**Pollutant Emissions**	
Power @ Plant Rating	1,400 kW	Exhaust Temperature	700 +/- 50 °F	NOx	0.01 lb/MWh
Standard Output AC voltage	480 V	Exhaust Flow	18,300 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)	2,216,000 Btu/h	CO_2	980 lb/MWh
Efficiency		(to 120 °F)	3,730,000 Btu/h	CO_2 (with waste heat recovery)	520-680 lb/MWh
LHV	47 +/- 2 %				



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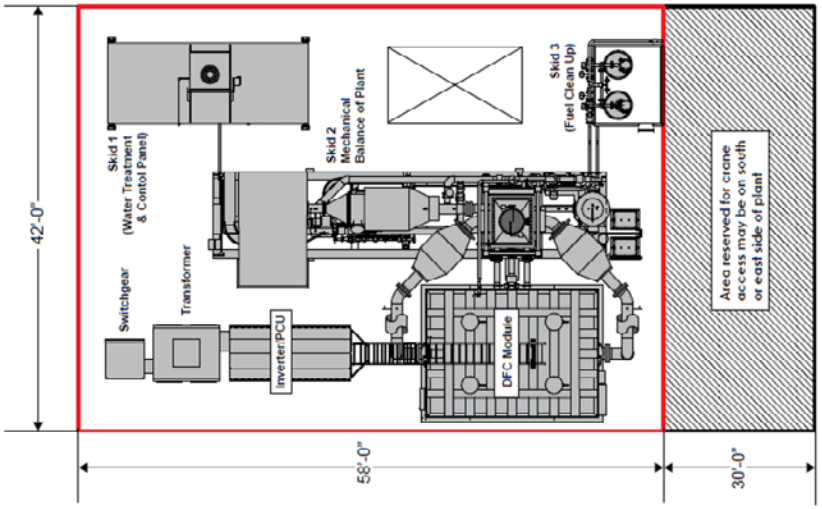

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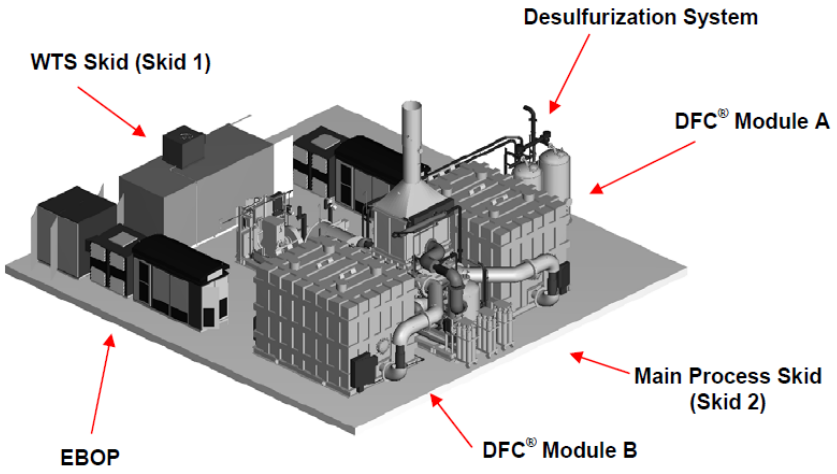
DFC®3000 Fuel Cell Power Plant

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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