



FuelCell Energy

World Leader in Ultra-Clean Power

Fuel Cell Power Plants Renewable and Waste Fuels

**DOE-DOD Workshop
Washington, DC.
January 13, 2011**

reliable, efficient, ultra-clean

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FuelCell Energy, Inc.

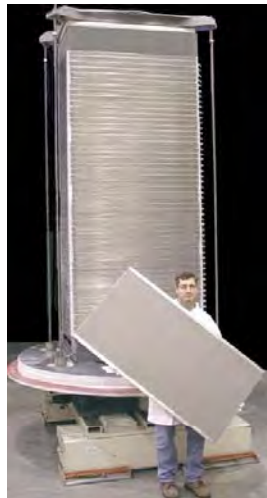
- Premier developer of stationary fuel cell technology — founded in 1969
- Over 50 installations in North America, Europe, and Asia
- Industrial, commercial, utility products
- 300 KW to 50 MW and beyond





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Product Line Based on Stack Building Block



Cell Package and Stack



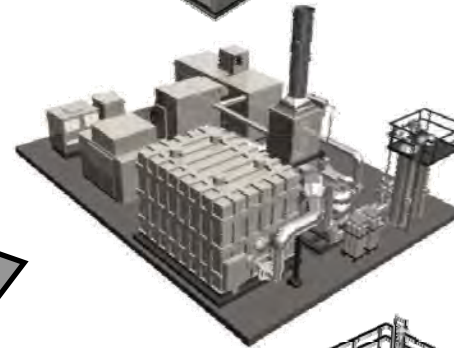
Single-Stack Module



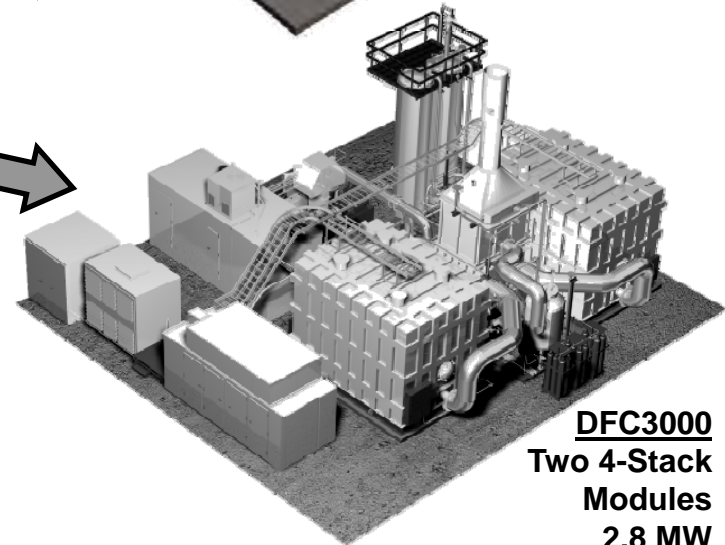
Four-Stack Module



DFC300
Single Module
Powerplant
300 kW



DFC1500
One 4-Stack
Module
1.4 MW



DFC3000
Two 4-Stack
Modules
2.8 MW



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DFC1500 Powerplant Subsystems

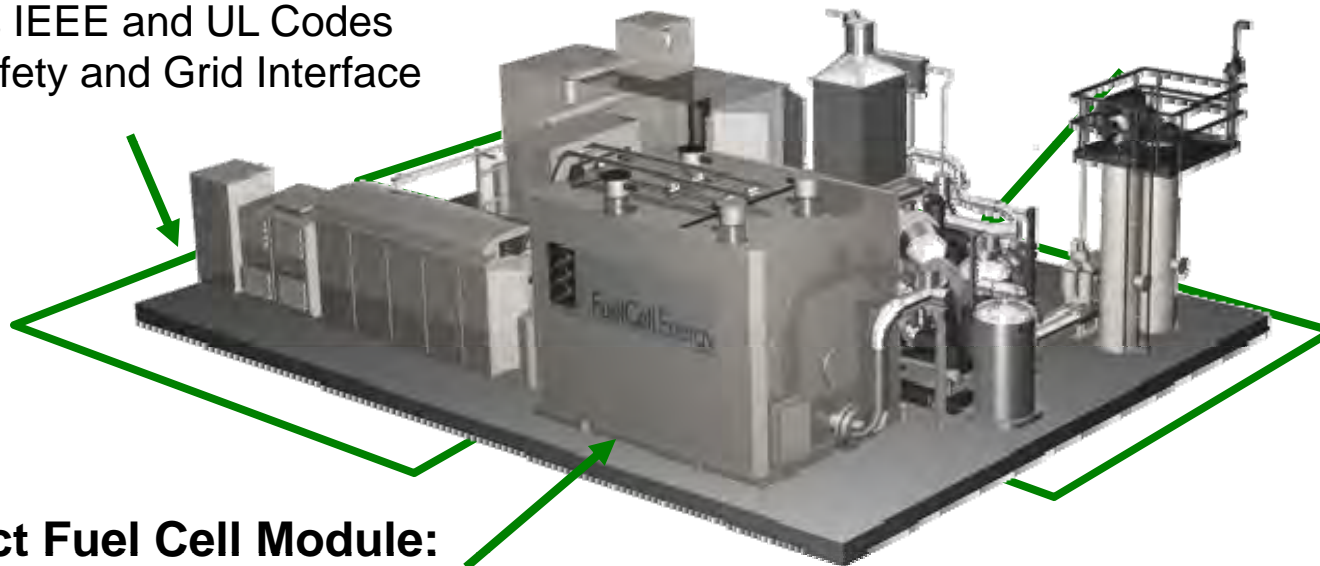
Electrical Balance Of Plant (EBOP):

- Converts DC power to grid quality AC power
- Meets IEEE and UL Codes for Safety and Grid Interface

Mechanical Balance Of Plant (MBOP):

- Water and Fuel flow cleanup and preheat
- Air supply, startup heater

Direct Fuel Cell Module: 4-stack Module





- **On-site self generation of combined heat and power**

- Clean Power with natural gas fuel
- Renewable Power with biofuels

- **Grid connected power generation**

- High Efficiency Grid support
- Renewable Portfolio Standards





Fuels Resources for DFC

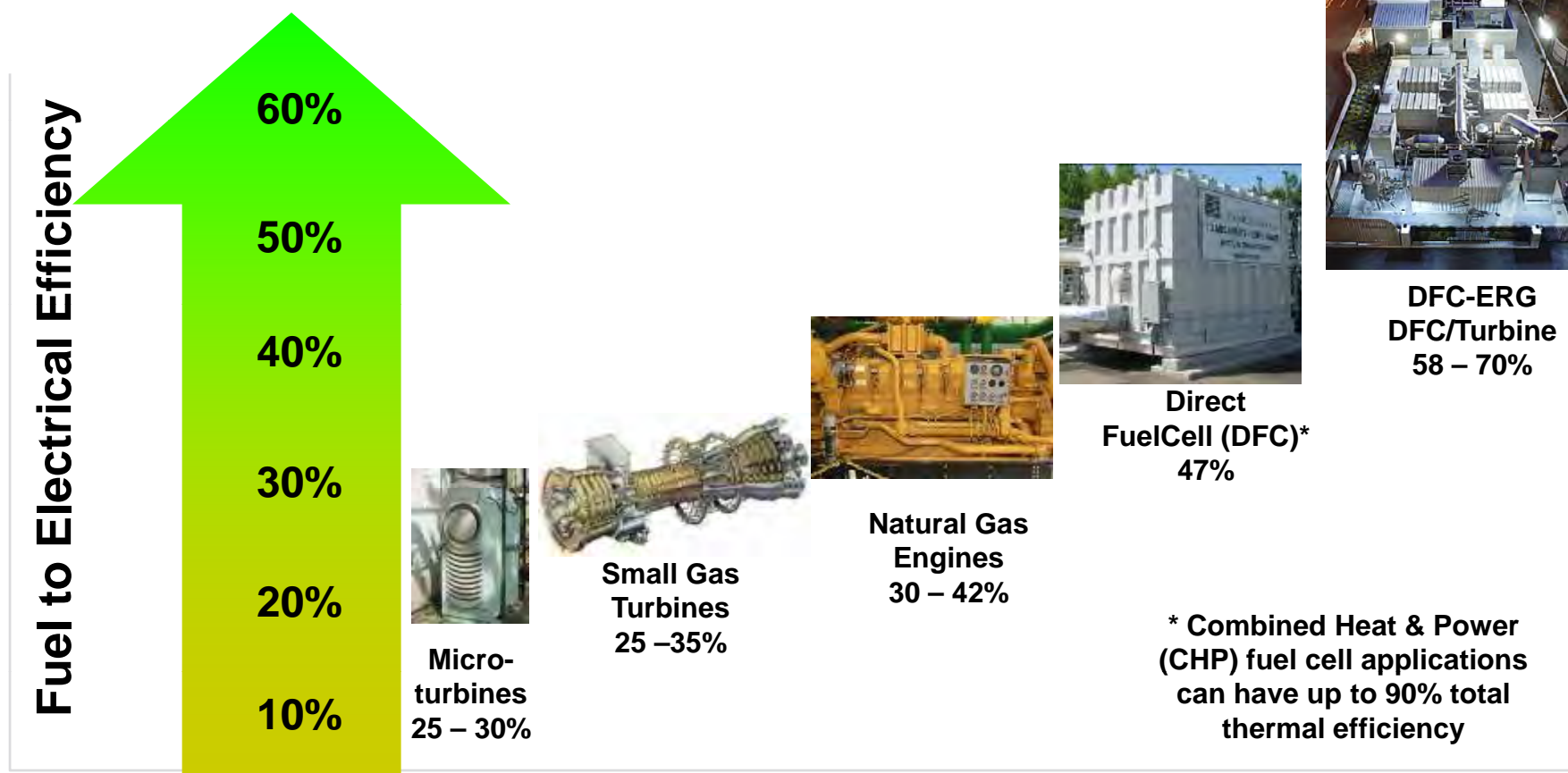
- Natural Gas and LNG
- Propane
- Biogas (by Anaerobic Digestion)
 - Municipal Waste Water Treatment
 - Brewery
 - Food and Animal Waste
- Biogasifier derived Fuels



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Comparative Electrical Efficiency

DFC power plants offer the high efficiency



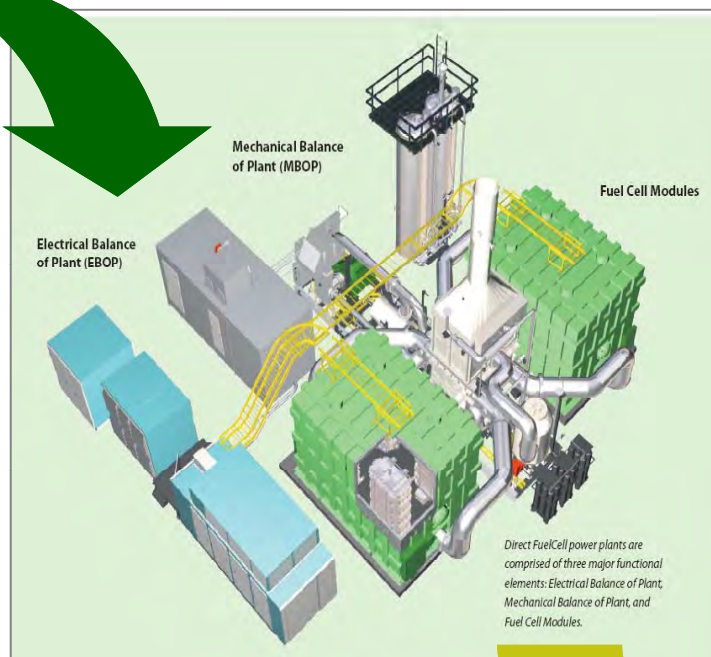
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Fuels Diversity and Efficiency

FUEL RESOURCES

- NATURAL GAS
- PROPANE
- ETHANOL
- WASTE METHANE
- BIOGAS
- COAL GAS



INTEGRATED SYSTEMS IMPROVE EFFICIENCY

- DFC – (47%)
- DFC – CHP (60-80%)
- DFC – ERG (55-60%)
- DFC/T – (55-60%)
- DFC H₂ (50-60%)

Diversity of Fuels plus High Efficiency – High Sustainability



	NOX (lb/MWh)	SOX (lb/MWh)	PM-10 (lb/MWh)	CO2 (lb/MWh)
Average US Grid	3.43	7.9	0.19	1,408
Average US Fossil Fuel Plant	5.06	11.6	0.27	2,031
Microturbine (60 kW)	0.44	0.008	.09	1,596
Small Gas Turbine (250 kW)	1.15	0.008	.08	1,494
DFC Fuel Cell 47% efficiency	0.01	0.0001	.00002	980
DFC Fuel Cell – CHP 80% efficiency	0.006	0.00006	.00001	552

Source for non-DFC data: “Model Regulations For The Output Of Specified Air Emissions From Smallscale Electric Generation Resources Model Rule and Supporting Documentation”, October 15, 2002; The Regulatory Assistance Project report to NREL



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DFC Advantages for Biogas

- **More power for given amount of biogas:** Higher efficiency than any other generation at typical digester facility sizes
- **Good heat to power ratio for digester support:** Fuel cell makes enough heat to support digester operation
- **Avoids generation of NO_x and other pollutants** from flare or from other generation technologies





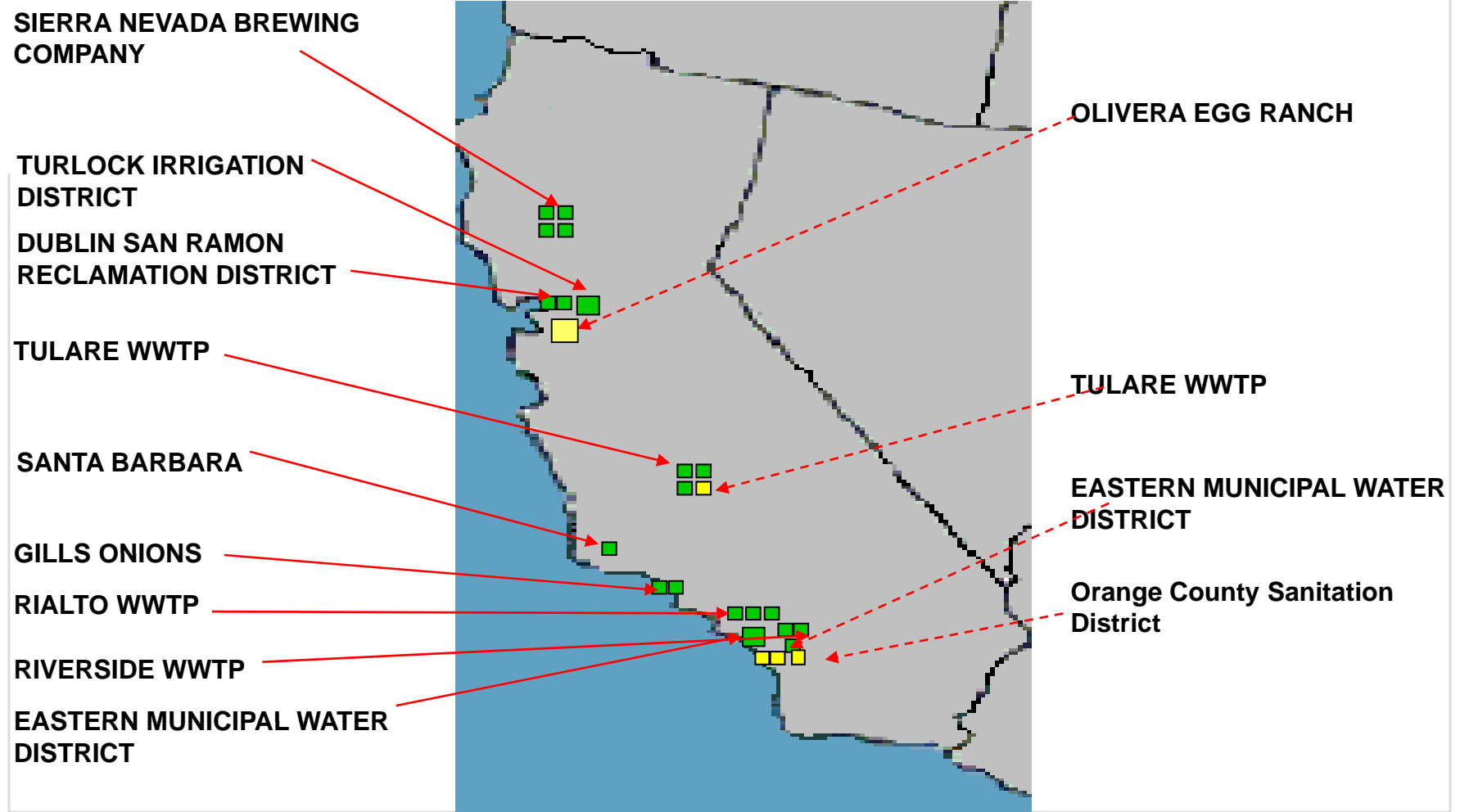
Typical Fuels Composition

Composition	Natural Gas	Biogases			
		Waste Water	Food Waste	Animal Waste	Landfill
Methane (Vol%)	80-100	~50-60	~50-70	45-60	40-55
Carbon Dioxide (Vol%)	<3	30-40	25-45	35-50	35-50
Nitrogen (Vol%)	<3	<4	<4	<4	<20
Oxygen (Vol%)	<0.2	<1	<1	<1	<2
H ₂ S, ppm	<0.1	<400	<10000	<300	<200
Non-H ₂ S Sulfur, ppm	<10	<1	<1000	<30	<30
Halogens, ppm	<0.1	<0.2	<0.2	<0.2	<100
Moisture, %	<0.02	~3	~3	~3	~3



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Bio-gas Plants in North America



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Tulare CA Wastewater Treatment Plant



- 3 DFC300 Units operating on ADG, provide ~ half of facility load
- 94% Availability from Jan 2008 through Aug 2010
- Recently ordered fourth unit



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4 DFC300 Plants Sierra Nevada Brewery, California



**Site With Power Generation in Excess of ADG Supply
First Site with Automated Fuel Blending**

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Turlock Irrigation District Waste Water Treatment Facility, Turlock, CA



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Gills Onion Food Processing Facility, Oxnard, CA



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Eastern Municipal Water District Waste Water Treatment Facility, Moreno Valley, CA



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VOC Solvent Fuel.

Ford Motor Company, Ontario Assembly

- Challenge:
 - Cost-effectively dispose of VOC*
 - Reduce emissions in paint operations
- Solution:
 - 300 kW Ultra-Clean 24/7 reliable power running on VOC
- Results:
 - Low-cost, low-emissions electricity
 - VOC disposal cost cut in half over ten years



* Volatile Organic Compounds



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DFC-ERG High Efficiency Application

- DFC-ERG designed for pipeline letdown operations
 - Byproduct heat warms gas to prevent freezing
 - Energy from pressure letdown fed to turbine
 - Combined electricity delivered to the grid
- Improved economics and lower CO₂ emissions
- 2.2MW Toronto plant demonstrating technology and validating value proposition
 - Efficiency greater than 70%



2.2 MW DFC-ERG in Toronto



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Co-Production of Renewable Hydrogen Orange County, CA



Orange County
Sanitation
District (OCSD)

Renewable H₂
Filling Station

ADG fueled
DFC-H2®
Production Unit



Energy Efficiency &
Renewable Energy

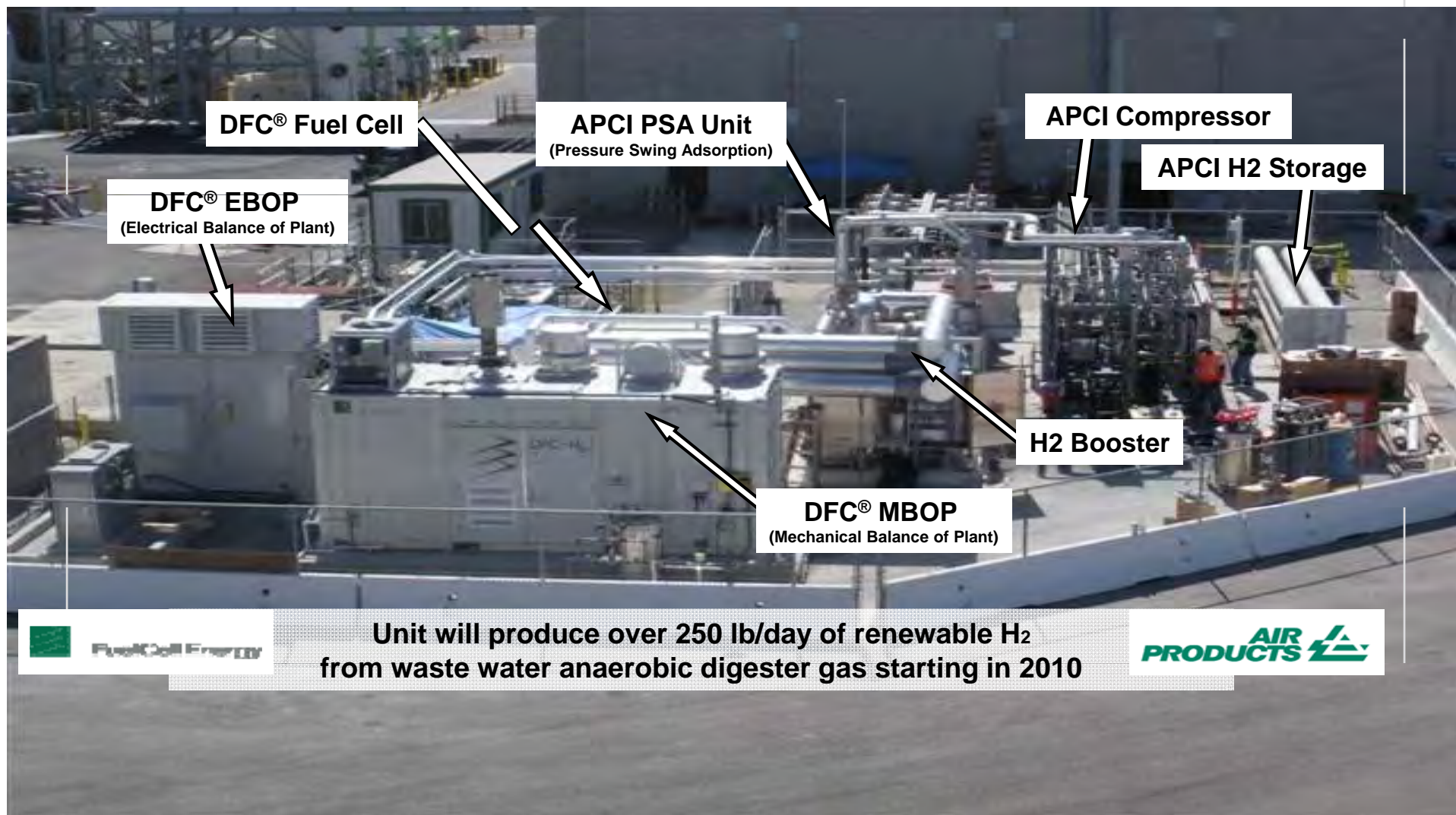




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Co-Production of Renewable Hydrogen Orange County, CA

First DFC-H₂[®] Unit Installation

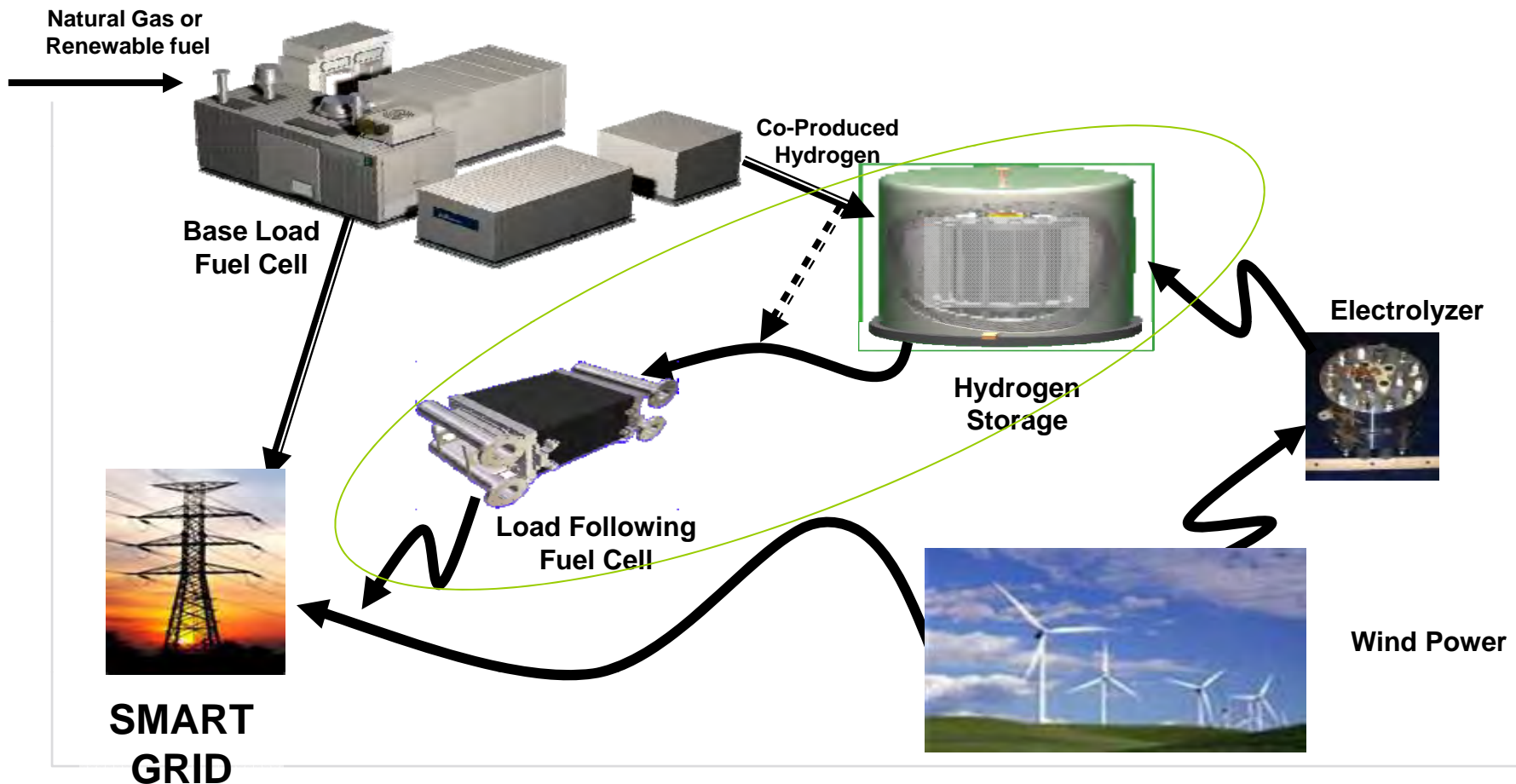




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Smart Grid Integration Power, Fuel and Energy Storage

DFC-H2® Peaker - Compliments Smart Grid



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Co-Production Capacity of DFC-H₂[®] Power Plants

DFC300[®]



DFC1500[®]



DFC3000[®]



Co-product

Power, kW	250	1,000	2,000
Hydrogen, kg/day	125	500	1,000
Heat, mmBtu/hr	0.5	2.0	4.0

Peaker Capacity

Peak Power (8 hrs/day), kw	500	2,000	4,000
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Refueling Capacity

Fuel Cell Cars, 0.5 kg/day	300	1,200	2,400
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