FuelCell Energy

World Leader in Ultra-Clean Power

Fuel Cell Power Plants
Biofuel Case Study – Tulare, CA

DOE-NREL Workshop

Golden, CO

June 11-13, 2012

reliable, efficient, ultra-clean

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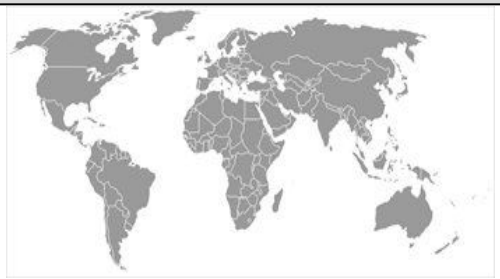
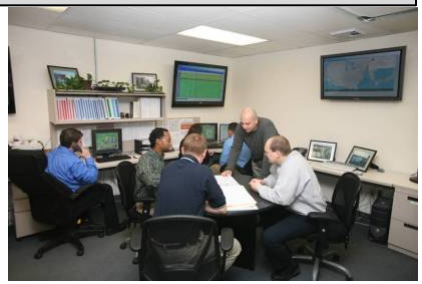
Integrated Fuel Cell Company

Manufacture **Sell** (direct & via partners) **Install** **Services**





Growing Market Presence

180 MW installed and in backlog	Over 80 Direct FuelCell® plants generating power at more than 50 sites globally	Providing: • On-site power • Utility grid support

Delivering ultra-clean baseload distributed generation globally

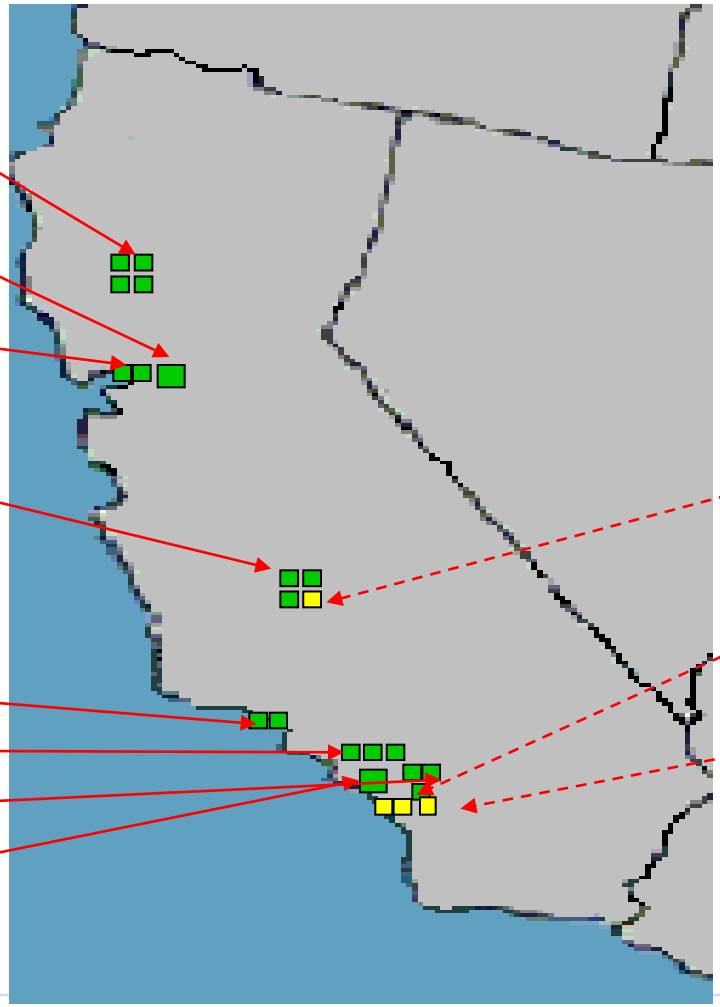
600 kW plant at a food processor

1.4 MW plant at a municipal building

2.4 MW plant owned by an Independent power producer

11.2 MW plant - largest fuel cell park in the world

FCE Bio-gas Plants



Municipal Waste Water Treatment

- **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

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Non-Municipal Applications

- Fuel Resource Diversity
  - Waste from food and beverage processing
  - Waste from other commercial processes
    - Biofuel production
    - Pharmaceutical Organics
- Other Factors
  - Access to Federal Tax Credits
  - Often smaller scale than municipal applications
  - Often not 24 x 7 operation, requiring alternate fuel for weekend operation

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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_2S, ppm	<0.1	<400	<10000	<300	<200
Non-H_2S 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

Natural Gas and Digester Gas Fuels

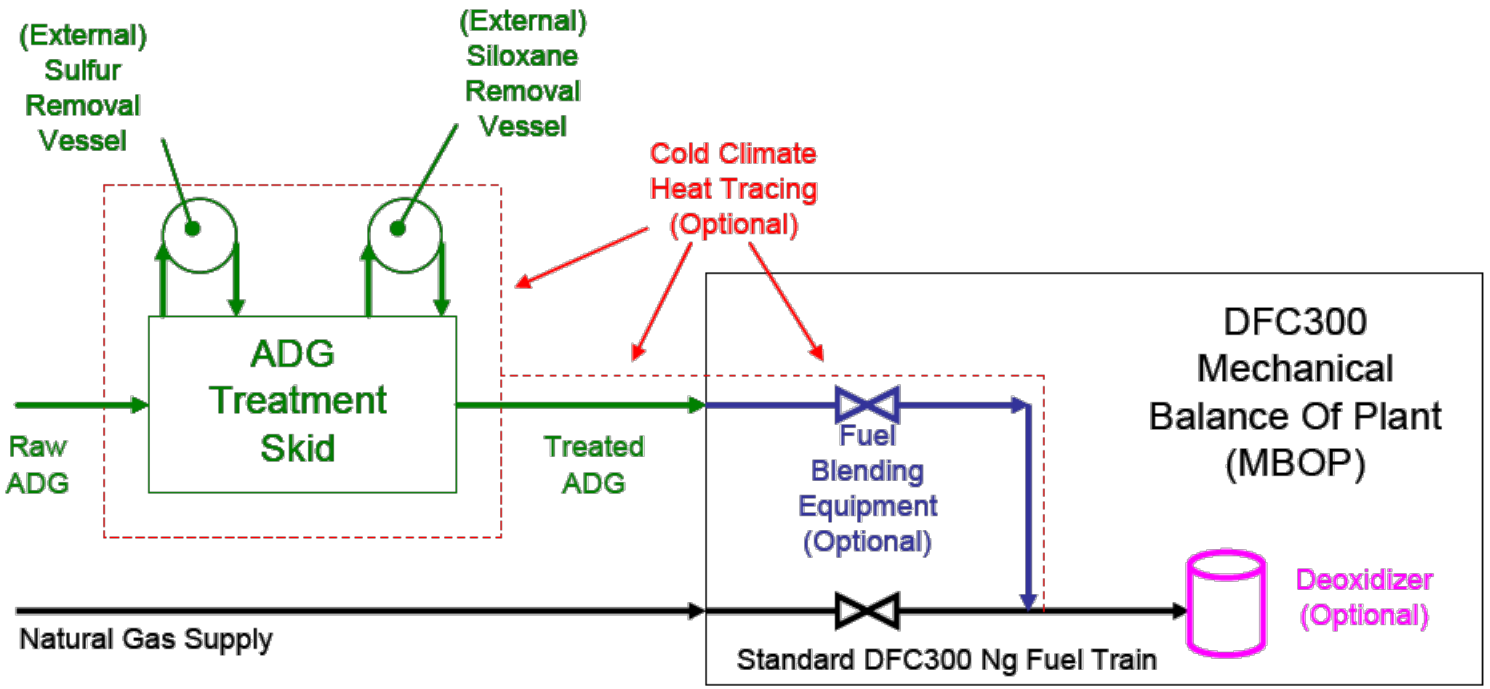
Natural Gas

- 90 – 100 % Methane, balance typically higher hydrocarbons
- 900 – 1000 Btu/ft^3
- Dry
- Very Low Oxygen, except peak shave gas
- Odorized for safety, typically 3ppm sulfur, max 20 ppm

Digester Gas

- 50% - 80% Methane (60% typical), balance typically CO_2
- 500 – 800 Btu, ft^3
- Saturated at digester temperature
- Fraction to a few percent Oxygen
- Sulfur present naturally, at tens to hundreds of ppm, also often contains Siloxanes

DFC Digester Gas Processing



Tulare CA WWTP

- Plant Flow – 11.5 MGD
- Digester Gas Production 500,000 SCFD
- Production of Biogas in Bulk Volume Fermentor (BVF)
- Electrical Demand 2,700 KW

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Tulare CA WWTP
Fuel Cell Plant

- 4 FCE DFC300 Fuel Cells 1200 KW (3 initial in 2008, 4th added in 2011)
- Biogas Treatment by Applied Filter Technology (H_2S, Siloxanes and VOC)
- CHP (Hot Water) Heat Recovery
- Electric Interface with Utility (SoCal Edison)

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Tulare CA WWTP

Fuel Cell and Ancillary Systems

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Tulare CA WWTP
Key Drivers for Fuel Cell

- Digester Gas Previously Flared
- Highest Efficiency Available (47%) for power generation
- Reduce Greenhouse gasses
- Emissions Exemptions and Rule 21 Qualification
- SGIP funding
- Dual Fuel (Natural Gas) Flexibility

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Commercial Site BioGas
Sierra Nevada Brewery, CA

DFC 300 CHP, 1MW, digester biofuel and natural gas

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Food Processing Facility
Gills Onions Oxnard, CA

600 KW DFC 300 Units, digester fuel, combined heat and power

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Fuel Cells
Biofuel Renewable Power

Market Drivers

Municipal and Industrial Facilities face disposal issues, a need for clean power to comply with clean air regulations, and ambitious sustainability goals

Fuel Cell Plants Provide Solutions

- Renewable baseload power solves waste disposal problem and provides continuous clean power
- Ultra-clean power facilitates ease of air permitting
- Distributed generation enhances power reliability and energy security
- High efficiency

Fuel Flexibility on varying BTU Gas

- Municipal Wastewater Biogas
- Brewery and Food and Animal Waste
- Biogasifier and Biofuel waste gas

Site Challenges need to be Addressed in Design

- Clean up systems required
- Varying biofuel availability