Microgrids and Distributed Hydrogen with SureSource Tri-generation Systems

October 2018
FuelCell at a Glance

Delivering Clean Innovative Solutions for the Global Supply, Recovery and Storage of Energy

**Snapshot**

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**Company Overview**

- FuelCell Energy designs, manufactures, undertakes project development, installs, operates and maintains megawatt-scale fuel cell systems.
- Serving utilities, industrial and large municipal power users with solutions that include:
  - Both utility-scale and on-site power generation
  - Carbon capture
  - Local hydrogen production for transportation and industry
  - Long duration energy storage

**Global Customers**

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SureSource Solutions

2.8 MW
SureSource3000™
47% Electrical Eff,
up to 90% Total Eff.

1.4 MW
SureSource1500™
47% Electrical Eff,
up to 90% Total Eff.

2.35 MW
SureSource
Hydrogen™
2.35 MW Power plus
1270 kg/day Hydrogen

3.7 MW
SureSource4000™
60% Electrical Eff.
Up to 80% total Eff

Larger Scale Fuel Cell Parks

59 MW
11 MW
15 MW

Individual fuel cell &
350 kW fuel cell stack

Completed module
1.4 megawatts

Four-Stack Module
1.4 megawatts

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SureSource Hydrogen Process (Tri-generation)

- **H₂ Separation**: 1270 kg/day SAE J2719 quality hydrogen
- **Fuel Exhaust Cooling**: 1 gpm net water production
- **Air Electrodes**: Water recycled to humidify fuel
- **Fuel Electrodes**: Power conversion and system internal loads
- **System Exhaust**: with 0.5 MMBtu/h available thermal energy

Hydrogen is produced from methane in the SureSource fuel cell stack modules, using fuel cell product water and waste heat to support reforming.

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Distributed Hydrogen Advantage

Natural gas as feedstock and thermal fuel
Water for steam reforming

Large Steam-Methane Reformer

Central Hydrogen and Long Distance Transport

Additional cost and emissions from transportation from central SMR to stations to filling stations

Fueling stations

On-site biogas or biomethane by pipeline is renewable power generation and hydrogen feedstock fuel

Clean / Renewable Power & Heat

Local distribution to stations

Onsite fueling station

On-Site and/or Local Distributed (<40 miles) Hydrogen using Trigeneration Fuel Cells

Efficient co-production of hydrogen with clean power and heat close to users

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Distributed Hydrogen Trigeneration systems produce hydrogen with fuel cell waste heat, avoids methane combustion and avoid cost & emissions of long distance truck transport.

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SureSource 1500 and 3000 power plants have achieved CARB DG Certification on Anaerobic Digester Gas under the California Distributed Generation Program 2013 Waste Gas Standards
Distributed Hydrogen Overview

Co-production of power with hydrogen improves economics to produce the most affordable hydrogen and generate state LCFS credits & potentially federal RINS

SureSource Hydrogen System

Renewable Feedstock:
On-site Biogas: 912 MCFD
Biomethane by pipeline: 540 MCFD (4263 GGE/day)

Backup fuel: natural gas

Transportation Energy Center

2.3 MW Clean and green power – 18 GWh/year
• 8,500 tons per year avoided grid CO₂ emissions with biogas fuel in California
• 1800 tons per year avoided grid CO₂ emissions with natural gas fuel in California
• 2 tons per year avoided NOX

1270 kg/day hydrogen
• 6200 tons per year CO₂ reduction from vehicles
• 8.9 tons per year NOX reduction from vehicles

0.5 MMBtu/h thermal energy
• 290 tons per year avoided boiler CO₂ emissions
• 0.1 tons per year avoided NOX

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Toyota to Build the World’s First Megawatt-scale 100% Renewable Power and Hydrogen Generation Station

Tri-Gen will generate on-site hydrogen to supply Toyota Fuel Cell Vehicles, including Project Portal Heavy-Duty Truck Concept

Toyota Logistics Services at the Long Beach Port will become first Toyota facility in North America to use 100% Renewable Power
Fuel Cell Microgrids

Fuel cells only:
Fuel cells can be the sole energy source for a micro-grid

Turnkey solution includes: designing and modeling the micro-grid & building, operating and maintaining the fuel cell power plant

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

Combined with other power generation systems:
Fuel cell micro-grids can operate in tandem with other on-site power generation technologies

Fuel cells provide dependable, clean energy 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.

- **Micro-grid 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
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 CO2, 64 tons SOx, 28 tons NOx
Fuel Cell - Only
- 1.4 MW Fuel Cell
- Load Follow Capable
- Black-Start Capable

Grid Connected Operation
- Base Load, Net Metering
- Heat to Campus

Microgrid Operation
- “Drop & Pickup”
- Microgrid controller sequences critical facilities.
- Inverter follows microgrid load.
- Load Leveler maintains fuel cell power constant.
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 – Town of Woodbridge, CT

Fuel Cell - Only
• 2.2 MW Fuel Cell
• Load Follow Capable
• Black-Start Capable

Grid Connected Operation
• Base Load
• Heat to High School

Microgrid Operation
• “Drop & Pickup”
• Microgrid controller sequences critical loads.
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• Load Leveler maintains fuel cell power constant.
Supporting the Advancement of California’s ZEV Fueling Infrastructure

Transportation Energy Center
Microgrid with Grid Outage Operations

Landfill Gas

Organic/Dairy Waste

Anaerobic Digesters

FuelCell Energy Tri-Gen

Biomethane by pipeline

On-site biogas

Onsite Electricity

Excess Water

Hydrogen 1270 kg/day

Onsite Hydrogen Fueling Station

Off Site Excess Hydrogen Deliveries

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Thank you

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