Distributed Hydrogen with SureSource Hydrogen Trigeneration Systems

February 2018
**Company Overview**

### Company
- **Design & Manufacture**
- **Project Development**
- **Turn-key Project Delivery**
- **Plant Operation**

- Delivering clean innovative solutions for the global supply, recovery and storage of energy
- Corporate office, R&D and global service in Danbury, CT
- Manufacturing in Torrington, CT
- More than 50 installations, several hundred MW installed on 3 continents
- Produced >7 billion kWh’s of ultra-clean power

### Markets

#### Energy Generation
- Ultra-clean
- Affordable
- Enhances Resiliency
- Easily sited

#### Carbon Capture
- Generates power while capturing CO₂
- Affordable capture from coal and NG sources

#### Distributed Hydrogen
- Generates power while producing H₂
- Affordable, clean, local H₂ production

#### Solid Oxide Based Power Generation, Electrolysis and Storage
- Efficient power generation, H₂ production, and hydrogen-based energy storage
FuelCell Power Generation Systems

- **Individual fuel cell & 350 kW fuel cell stack**
- **Four-Stack Module 1.4 megawatts**
- **Completed module 1.4 megawatts**
- **1.4 MW SureSource1500™**
  - Utilizes one module
  - 47% Electrical Eff, up to 90% Total Eff.
- **2.8 MW SureSource3000™**
  - Utilizes two modules
  - 47% Electrical Eff, up to 90% Total Eff.
- **3.7 MW SureSource4000™**
  - Utilizes three modules
  - 60% Electrical Eff. Up to 80% total Eff.
- **59 MW fuel cell park**
Distributed Hydrogen Production

Hydrogen is produced as byproduct of fuel cell process, efficiently and without water consumption
SureSource Fuel Cell Operating Principle

- Internal reforming of methane to hydrogen
- Methane reforming heat is provided by fuel cell waste heat
- Methane reforming water is provided by fuel cell product water
- Electrochemical conversion of fuel to power is more efficient and avoids products of combustion emissions
Standard System:
- Natural gas or biogas fuel is efficiently converted to hydrogen inside fuel cell stack, using fuel cell waste heat
- Most $H_2$ used to produce power.
- Residual $H_2$ used to pre-heat fresh air

Trigeneration System:
- Same process, but residual $H_2$ is extracted and purified for external use
- $H_2$ is produced very efficiently, using waste heat from fuel cell power generation, and water produced by anode reactions
- Air pre-heat done by heat exchange with exhaust gas
- Similar to CO$_2$ capture, but $H_2$ is extracted from anode exhaust instead of CO$_2$

*Trigeneration is modification of standard SureSource system*
Distributed Hydrogen Trigeneration systems produce hydrogen with fuel cell waste heat, avoids methane combustion and avoid cost & emissions of long distance truck transport.
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.
SureSource Hydrogen System

Power Output, kW 2,350
Hydrogen Production, kg/day 1,270
Vehicle emissions reductions:
  NOX reduction, tons/year 8.9
  Particulate reduction, tons/year 1.8
  GHG reduction, tons/year 6,200

Modification of SureSource 3000 Powerplant
  Produces enough hydrogen for ~1500 cars or 30 busses refilling a day
  Generates enough electricity for ~2,350 average-sized homes
  Emission reductions are vs standard cars - Additional reductions from clean power
Port of Long Beach Project

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*
Supporting the Advancement of California’s Hydrogen Fueling Infrastructure
Thank you