Clean Energy Systems, Inc.

Up-Date On Oxy-Fuel Combustion

McIlvaine Hot Topic

January 2013
Clean Energy Systems, Inc.

Presentation Outline

• Company Background

• Technology Overview

• Markets and Product Development
Company Background
Company Background

History and Recent Developments

- Founded in Sacramento, California by former Aerojet (a GenCorp company) aerospace engineers; incorporated in 1996
- Specialize in oxy-fuel power generation
- CES technology portfolio
  - 20 MWt 4" Oxy-Fuel Gas Generator
  - 200 MWt 12" Oxy-Fuel Gas Generator
  - 30 MWt Oxy-Fuel Reheaters
  - 150 MWe Oxy-Fuel Turbine
  - 30 – 45 MWe peaking oxy turbine
- 30 patents issued on zero-emissions oxy-combustion technology power cycles, 36 patents pending
- Owner of two power plants: Bakersfield and Santa Clarita, CA
Company Background
Equity and Strategic Partners

**Equity Partners**

**Paxton Corporation** is an energy-focused company based in Calgary, Alberta; aggregator of technologies including CES’ oxy-fuel combustor for use in the extraction of hydrocarbons; significant equity position currently held by the largest shareholder of Paramount Resources Ltd.

**Southern California Gas Company** (a subsidiary of Sempra Energy; $16.0 B+ market capitalization) sells, distributes, and transports natural gas in the United States.

**The AES Corporation** ($8.5 B+ market capitalization) is a global power company with generation and distribution businesses.

**Strategic Partners**

**Maersk Oil** (subsidiary of A.P, Møller – Maersk A/S. with a $29 B+ market capitalization) is an international oil and gas company with operated production of about 625,000 barrels of oil (equivalent) per day. A licensee of CES technology.

**Siemens Aktiengesellschaft** ($80 B+ market capitalization) is a diversified international electrical and engineering company that provides solutions to the energy and other sectors. A development partner with CES.

**Paramount Resources Ltd.** ($2 B+ market capitalization) is an independent energy company that engages in the exploration, development, and production of natural gas, crude oil, and natural gas liquids in North America. A licensee of CES technology

**US Department of Energy** works together with the country’s private sector to develop and foster new technologies to ensure America’s long-term energy security.

**LM Alternatives Inc.** and its sister companies have been providing quality parts and related services to turbo machinery users in industrial, utility and aviation applications for more than four decades.
Company Background

CES Facilities
**Company Background**

The World’s Largest Oxy-Fuel Facility
CES Technology Overview
CES Technology Overview

The TriGen™ Oxy-Fuel Cycle

- Air
  - Air Separation Plant
  - N₂
  - O₂

- Fuel Processing Plant
  - Crude Fuel
  - Fuel
  - CO₂ Recovery
  - CO₂: 2,300 TPD
  - Water: 508,000 GPD
  - NG, Oil or Landfill Gas
  - Coal, Refinery Residues, or Biomass
  - Direct Sales
  - EOR, ECBM, or Sequestration

- Gas Generator
- Multi-stage Turbines
- Elect Gen.
- HX
- Cond.
- C.W.
- Excess Water

- 209 MW
• **CES Combustor Technology:**
  ➔ Hundreds of individual platelets are photo-etched to form 3-D channels
  ➔ Precisely stacked platelets are pressure bonded into a monolithic structures
  ➔ Intricate pathways channel fuel, oxygen, and water into hundreds of combustors
  ➔ Intimate, stoichiometric mixing for complete combustion
CES Technology Overview

12” Gas Generator Combustor Face
CES Technology Overview

12” Gas Generator
**CES Technology Overview**

Oxy-Fuel Re-Heater Assembly for the OFT-900
CES Technology Overview

Technology Development Plan

- **1st Generation**
  - Proof of concept, Kimberlina steam turbine: 4” GG;
  - 20-30% η; 50 MW; 2nd Generation
  - J79, indirect cycle, or STG - Deploying

- **2nd Generation**
  - 35-45% η; 200 MW; 3rd Generation
  - CES/Siemens/TriGen OFT 900 Developing

- **3rd Generation**
  - 50% η; 400 MW; CES/Siemens/TriGen
Markets and Product Development
Markets and Product Development

Ongoing Market Applications

- Zero Emission Power Plants
  - Power or CO2 as the Primary Product
- Monetizing Opportunistic Fuels
  - Low BTU Gas, Syngas, Bitumen, Biofuels, etc.
- Maersk Trigeneration: Power, CO2 for EOR and Water
  - See: http://www.maerskoiltrigen.com/
- SAGD and Heavy Oil Recovery
- Peaking Power Plant
- Zero Emission Load Balancing
- Energy Storage To Optimize Renewable Energy

Ongoing project development
Markets and Product Development

The TriGen™ Oxy-Fuel Cycle

- Air Separation Plant
- Fuel Processing Plant
- Fuel
- Crude Fuel
- Coal, Refinery Residues, or Biomass

- NG, Oil or Landfill Gas
- CO₂ Recovery

- Gas Generator
- Multi-stage Turbines
- Elect Gen.

- HX
- Cond.
- C.W.
- Excess Water
- Direct Sales
- CO₂
- Recycle Water
- EOR, ECBM, or Sequestration

CES/DOE ARRA Project
SGT to OFT and Reheaters
(comb. air to 2,200F steam)

209 MW
CO₂: 2,300 TPD
Water: 508,000 GPD
Markets and Product Development
Turbine Removal from Abitibi Bowater Facility: March 2011
Markets and Product Development

SGT-900 Disassembly and Inspection: June 2011

Compressor blades removed.

Gas flow from 12” GG.

Turbine blades left in place.

Reheaters installed.
Markets and Product Development

Turbine Shaft With Power Turbine Blades Re-Installed: May 2012
Markets and Product Development

Completed OFT-900
Markets and Product Development

OFT-900 Re-Heater Test Stand
Applicable Markets

- Peaking power facilities (<10% CF)
- Enhanced gas and oil recovery
- Off-spec gas utilization
  (approximately one-third of future gas production)

Product Advantages

- Low capital cost
- Small footprint and modular
- Effectively zero NOx and PM
- Fast power ramp up to full load <2 min.
- 4.4 hours @ max power
  with 50,000 gallon O₂ storage
The End