Pressurized Oxy-Combustion of Coal: Zero Emissions Power Plants

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Introduction

Clean Energy Systems (CES)

- Founded in 1993 by retired aerospace engineers, Incorporated in 1996
- Located in California:
  - Headquarters: Sacramento, Ca
  - Demonstration Plant: Bakersfield, Ca
- Issued 25 patents on zero-emissions oxy-combustion power cycles
- Focused on process rights (IP) and manufacturing enabling technology – oxy-fuel combustors & turbine
Vision

A new way to make power without pollution.

We use aerospace technology to change the way power is produced, and eliminate atmospheric emissions.
The CES Process

Air

N2

O2

Air Separation Plant

Fuel Processing Plant

Crude Fuel

Fuel*

Gas Generator

Multi-stage Turbines

Elect Gen.

CO2

Recovery

CO2

Cond.

C.W.

HX

EOR, ECBM, or Sequestration

Direct Sales

Recycle Water

Excess Water

NG, Oil or Landfill Gas

Coal, Refinery Residues, or Biomass

* CH4, CO, H2, etc.
Main Features
“Oxy-Turbine” vs. “Oxy-PC”

- Differs from other oxy-combustion processes:
  - Combustion takes place at high pressure (up to 100 bar)
  - Water/steam/CO\(_2\) used for temperature moderation
  - Combustion products (steam/CO\(_2\)) directly drive steam turbines and/or modified gas turbines

+ High cycle efficiencies
+ Near 100% CO\(_2\) capture
+ Multi-fuel capability
  - Requires advanced turbines
  - Requires gasification
  - Less retrofit-friendly
Unique Factors

- Zero Atmospheric Emissions
- Base Load
- Scalability
- Multi-Fuel
- Patent Protected
- Proven Technology

20 MW, Gas Generator

- Compact and lightweight
- 25 tph steam/CO₂
- Market potential for thermal EOR
- Market for small cogeneration
Commercial Gas Generator

- Suitable for 50 - 200 MW Plants
- 250 tph steam/CO2
- Compact
First Generation Turbine

• Originally a GE J79 turbine
• Used for 12 MW industrial applications (at right)
• Converted to a 40 MW oxy-turbine (below)

• “No-load” testing commenced in 2010. “Load testing” to be completed 1Q 2011
Oxy-Fuel Test Facility: World’s Largest

Solar Thermal Demo Plant
Oxygen System
Liquid Fuel System
Gas Generator
Reheater
Vent Stack
J79 Turbine
Gas Generator
2nd Gen O-F Turbine System

DOE Funded:

- **Objective**: Design, Develop & Test a Commercial-Scale Oxy-Fuel Turbine (OFT) for use in Industrial O-F Plants
  - Capture and Sequester 99% of produced CO₂
  - Competitive Cycle
  - Using Diverse Fuels

- Used SGT-900 purchased Jan 2011
- Ready for testing July 2012
Technology Deployment

2004  2012  2015  2020

Proof of concept 5 MWe Kimberлина demonstration

37-43% η, 200 MWe
Second Generation Plant, based on Siemens SGT-900

27-32% η, 50 MWe
First Generation Plant, based on J79

45-53% η, 400 MWe
Advanced turbines: DOE

Future Potential

Note: Efficiencies shown are for natural gas plants
Syngas efficiencies are 7-8 percentage points lower
Our Products (and customers)

- Captured CO$_2$ for EOR/EGR
- Steam or CO$_2$ for Heavy Oil EOR, UCG
- Excess water (from the combustion)
- Zero Atmospheric Emissions Electricity
- Broad range of fuels: gaseous (gasified coal), solid, or liquid
- Water, Hydrogen, Other Products
- Peaking Power (no carbon capture but no NO$_x$, cheap and fast)

- The key to zero emissions coal plants: Industrial scale, with sale of CO$_2$ and Electricity
Thank you!