Oxy Fuel Turbine Technology Development Program Overview

Siemens Energy
Clean Energy Systems
# Siemens Energy Sector – Answers for Energy

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<th>Sectors</th>
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| Industry      | ■ Industry Automation  
■ Drive Technologies  
■ Building Technologies   | ■ Osram  
■ Industry Solutions  
■ Mobility  
■ Automation and Drives (A&D)  
■ Industrial Solutions and Services (I&S)  
■ Siemens Building Technologies (SBT)  
■ Osram  
■ Transportation Systems (TS) |
| Energy        | ■ Oil & Gas  
■ Fossil Power Generation  
■ Renewable Energy   | ■ Energy Service  
■ Power Transmission  
■ Power Distribution  
■ Power Generation (PG)  
■ Power Transmission and Distribution (PTD)  
■ Industrial Solutions and Services (I&S OGM) |
| Healthcare    | ■ Imaging & IT  
■ Workflow & Solutions  
■ Diagnostics   | ■ Medical Solutions (Med)                                                                                 |
Innovation fields along the entire energy conversion chain
Oxy Fuel Plant Concept

Air Separation Plant

Fuel Processing Plant

Gas Generator

Multi-stage Turbines

Elect Gen.

HX

Cond.

CO₂ Recovery

EOR, ECBM, or Sequestration

Direct Sales

Flexible Fuels, including:
- High CO₂ gas
- Flare gas
- Non-merchant associated gas

Fuel

O₂

N₂

Flexible Fuels, including:
- CH₄, CO, H₂, etc.

Excess Water

C.W.

Excess Water

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Energy Oil & Gas
- Combustion Technology for injector design promotes intimate mixing and cooling
**Oxy Fuel Plant Concept**

- **Air Separation Plant**
  - Air
  - \( N_2 \)

- **Fuel Processing Plant**
  - Fuel
  - Flexible Fuels, including:
    - High CO2 gas (25-50%)
    - Flare gas
    - Non-merchant associated gas

- **Gas Generator**
  - \( O_2 \)
  - Fuel*

- **Multi-stage Turbines**
  - HP
  - IP
  - LP
  - Elect Gen.

- **CO₂ Recovery**
  - \( CO_2 \)
  - Direct Sales
  - EOR, ECBM, or Sequestration

- **Cond.**
  - C.W.
  - Excess Water

- **HX**

- **Elect Gen.**

Flexible Fuels, including:
- High CO₂ gas (25-50%)
- Flare gas
- Non-merchant associated gas

* \( CH_4, CO, H_2, etc. \)
Power Turbine

1 - MATERIALS RESEARCH FOR CO2/STEAM PROCESS
2 – OXYFUEL REHEATER DEVELOPMENT
3 – POWER TURBINE DESIGN AND MANUFACTURE

OXYFUEL REHEATERS
POWER TURBINE
NO COMPRESSOR
PLENUM – HOT GAS INTAKE
Development History

- Past Development:
  - 1999: First demonstration of CES oxy fuel technology done under CEC grant
  - 2000-2003: 20MWt generator tested under DOE grant
  - 2002-2006: 2.7 MWe pilot-scale oxy fuel plant commissioned and connected
    > Over 400 starts and 2,000 running hours
  - 2006-2010: 170 MWt CES combustor tested with 1st generation oxy fuel turbine
- Current: DOE grant awarded to CES in partnership with Siemens
  - USD $30M awarded Sep 2010
  - Goal: Development of 2nd generation oxy fuel gas turbine technology
  - CES to further enhance combustor technology
  - Siemens to design, manufacture, and package oxy fuel turbine
  - DOE project completion: 2012
SIEMENS – Demonstration Turbine Manufacturing

Turbo Care Houston – Oxyfuel Core Manufacture
• 140,000 Sq. Ft. Facility, 100 Ton Capacity
• Full machine shop with lathes capable to work 130” diameter and 75 Tons
• Full in-house disassembly, reassembly and alignment capability of turbomachinery
• Operating speed rotor balance bunker
• Advanced welding capabilities

Oil & Gas Houston – Oxyfuel Packaging Assembly
• 50,000 Sq. Ft. Shop Bays, 100 Ton Capacity
• Sales, Engineering, Project Management, Procurement, and Packaging of Turbomachinery for the Americas
• Gas turbines, compressors, generators, motors, and auxiliary and balance of plant systems
• Full load package string test facility up to 16MW
Technology Targets

2nd generation Oxy Fuel Turbine Cycle capable of producing:

- Up to 150 to 200 MWe net power = 200,000 to 270,000 hp compression
  - Start and synchronize to grid within 10 minutes
  - No NOx
- 36-41% cycle efficiency
  - Includes CO₂ capture/compression, and O₂ separation/compression
  - Use of low calorific and non-merchant fuels (25%-90% CO₂)
- 54 MMSCFD CO₂ → enhanced oil recovery
- 13,100 BWPD net produced, or 190 kpph steam → net water!
- 500 MMSCFD N₂ → ??

Oxygen
Flex Fuel

Linarily Scalable Up or Down.
CO2 Compression

Compressor Conditions:
P1 = 15 psia (1 bar)
P2 = 2,165 psia (150 bar)
Flow = 100 MMSCFD
T1 = 43 F
MW = 43.9 (CO2)
Power = 23,600 HP
Questions?

Industry

We solve the challenges of a booming population

Healthcare

We supply better and affordable healthcare

Energy

We lower CO₂ emissions with our energy solutions

Source: Siemens