Oxy-Combustion for CCUS

“We are passionate about innovation and technology leadership”

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Oxy-combustion Development Path

Oxy-coal Combustion Development

- Multiple Oxy Eng Studies, including ASU / CPU Optimization & Process Heat Integration completed
- Small & Large Scale Oxy Pilot testing, completed, Lacq Oxy-Gas & CPU test, Callide CPU test in progress
- Reference plant design complete at 680/450 MWe net SCPC
- Next step - FutureGen 2.0

FutureGen 2.0 - 200MWe gross

Small pilot 1.5 MWth

Large pilot 30 MWth

2000

2008

2016
Combustion Performance

- Significant NOx reduction verified
- CO slightly lower with oxy-combustion
- LOI similar for air or oxy
- Attached stable flames with all fuels

NOx Reduction Air vs. Oxy Firing

- Bituminous DRB-XCL Burner
- PRB Enhanced Ignition Burner
- Lignite PAX-XCL Burner

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**Wet Scrubber Performance**

**SO₂**

- Relative performance showed oxy-firing SO₂ removal 5% to 10% better than air-firing removal (91.2% to 92% SO₂ removal)

![SO₂ Removal Graph](image)

**WFGD Tower Installation**
Oxy-Coal Combustion Principles

**Conventional Combustion**

- Oxygen
- Nitrogen
- Flue Gas after WFGD
- 100% flow rate to stack

**Oxy-Coal Combustion**

- Oxygen
- CO₂
- + Coal
- Nitrogen
- Flue Gas to CPU
- Flow rate to CPU

25 to 30% flow rate to CO₂ capture process
Oxy-Coal Plant Configuration

**ASU**
- Air In
- Pure Oxygen (O₂) Out
- Nitrogen (N₂) Out

**Boiler Island**
- Coal In
- Recycled Flue Gas
- CO₂ and Flue Gas
- Environmental Cleanup Equipment
- Ash
- H₂O
- SO₂
- Other Captured Emissions

**CPU**
- Other gases (NCGs)
- CO₂ Compression
- CO₂ Capture (liquid)
Future Gen 2.0 Project Participants

Power Generation & CO2 Capture

CO2 Transport and Storage
Oxy Project Objectives

Prove the Oxy-combustion process at commercial scale

- Establish a cost and schedule baseline for the technology
- Equipment Design Considerations – Primarily Boiler
  - Reliability – component design, materials of construction
  - Maintainability – erosion, corrosion, outage cycles
  - Not designed for high efficiency – designed for flexibility & learning
  - Prove basic process and heat transfer parameters – can move to higher efficiency, larger capacity w/o incremental steps
- Process Designs
  - Safety, Functionality, Operability
- Integrated operation of ASU – Boiler & AQCS – CPU – Storage
  - Start-up, Shutdown, Load Swing, Capacity Factor, System Dynamics
FutureGen 2.0 – Oxy-Combustion Project

Meredosia Plant

• Meredosia, IL: Owned by AER

• 3-coal fired units (2 retired)

• Unit 4, 200 MWe oil-fired boiler built in 1975, 2400 psig 1000/1000F Steam Cycle, low operating hours

• 3500 TPD CO2 to Storage
Not the optimal equipment arrangement for a new plant but the best possible in this case due to site space limitations. Will be a common occurrence with existing plant retrofits and repowering.
Plant Equipment Layout

- Boiler
- Coal Bunkers
- Ash Silo
- PJFF
- ID Fans
- PR Fans
- SR Fans
- Recycle Heater (Airheater)
- ASU
- WFGD
- DCCPS
- Gypsum Pile
- CPU
- Reagent Prep

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Oxy-Combustion Pros

- Boiler and AQCS equipment utilize conventional designs, materials of construction and arrangements. Combination of equipment and processes that are known to industry users.
- Pilot Testing results indicate that the oxy process will operate like a conventional power plant. Minimal impact to boiler combustion and little change to thermal performance. AQCS performance is unchanged.
  - Furnace and Heating surface
  - Pulverizers
  - Burners
  - FGD Systems
  - Baghouse and ESP
  - Basic Process Controls
Oxy-Combustion Pros Cont’d

- Oxy process can utilize a wide variety of coals including lignite, sub-bituminous and bituminous fuels
- For retrofit or repowering it is a less complex integration into the existing plant energy balance than PCC
- No new chemicals or waste streams are introduced into the plant process. Bottom ash, fly ash, FGD waste streams unchanged.
- No major change to the plant water balance. For low rank fuels may be a positive water balance from condensation of water from the flue gas stream
Oxy-Combustion Challenges

- Cost – CAPEX and OPEX but no different than the other CCS technologies
- Auxiliary Power – same here Oxygen making and CO2 Compression are still energy intensive
- Not a partial capture technology – all or nothing
- Need to prove the integrated operation of a large scale
  ASU – Boiler /AQCS – CPU coupled with the CO2 transportation and storage facility
  Start-up, Shut-down, Load Swings, Upsets
FG 2.0 Project Status—
Phase 1 Pre-FEED Accomplishments

- Phase 1 Pre-FEED work achieved
  - Plant Design and Equipment Arrangements
  - Existing Plant Assessment
  - Preliminary Plant Performance
  - Detail Project Cost Estimate
  - Preliminary Project Schedule
  - Preliminary Construction Plan
Current Status

• For business reasons unrelated to FutureGen 2.0, Ameren’s leadership role on project will be reduced
• Ameren will continue providing support
• FutureGen Alliance is requesting DOE’s approval to assume Ameren’s leadership role on the power plant component of the project
  • Ameren finalizing terms of sale for the plant with the Alliance
  • Business structure changes promise additional cost savings
• Value engineering ongoing to identify additional cost saving opportunities
• State of Illinois has initiated a process that will lead to an investment-grade power purchase agreement
• Anticipate start of FEED July 2012
Summary

- Development of commercial near-zero emission coal-fueled power plants has proved challenging in the current economic and regulatory environment
  - Many project cancellations on many continents

- Oxy-Combustion offers great promise as a competitive solution for CO2 capture from coal fired plants

- FutureGen 2.0 continues to be the nation’s best hope for a near-zero emission coal-fueled power plant
  - >90% Carbon Capture at 1.3 MMT/yr
  - Near-zero emissions for conventional pollutants
  - Fully integrated pipeline and storage
  - Deep saline storage – the workhorse geology in carbon-constrained world with CCUS
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