power generation group

Oxy-Combustion for CCUS

"We are passionate about innovation and technology leadership"

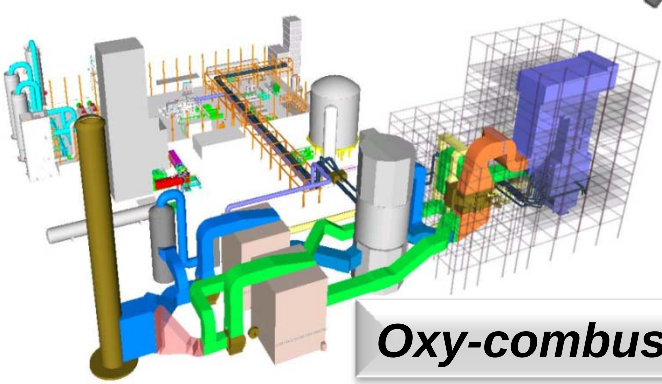
Steve Moorman
Manager -Business Development
Advanced Technology

clean energy technologies

Solar Receivers

B&W mPower
a progressive energy solution

Biomass Systems

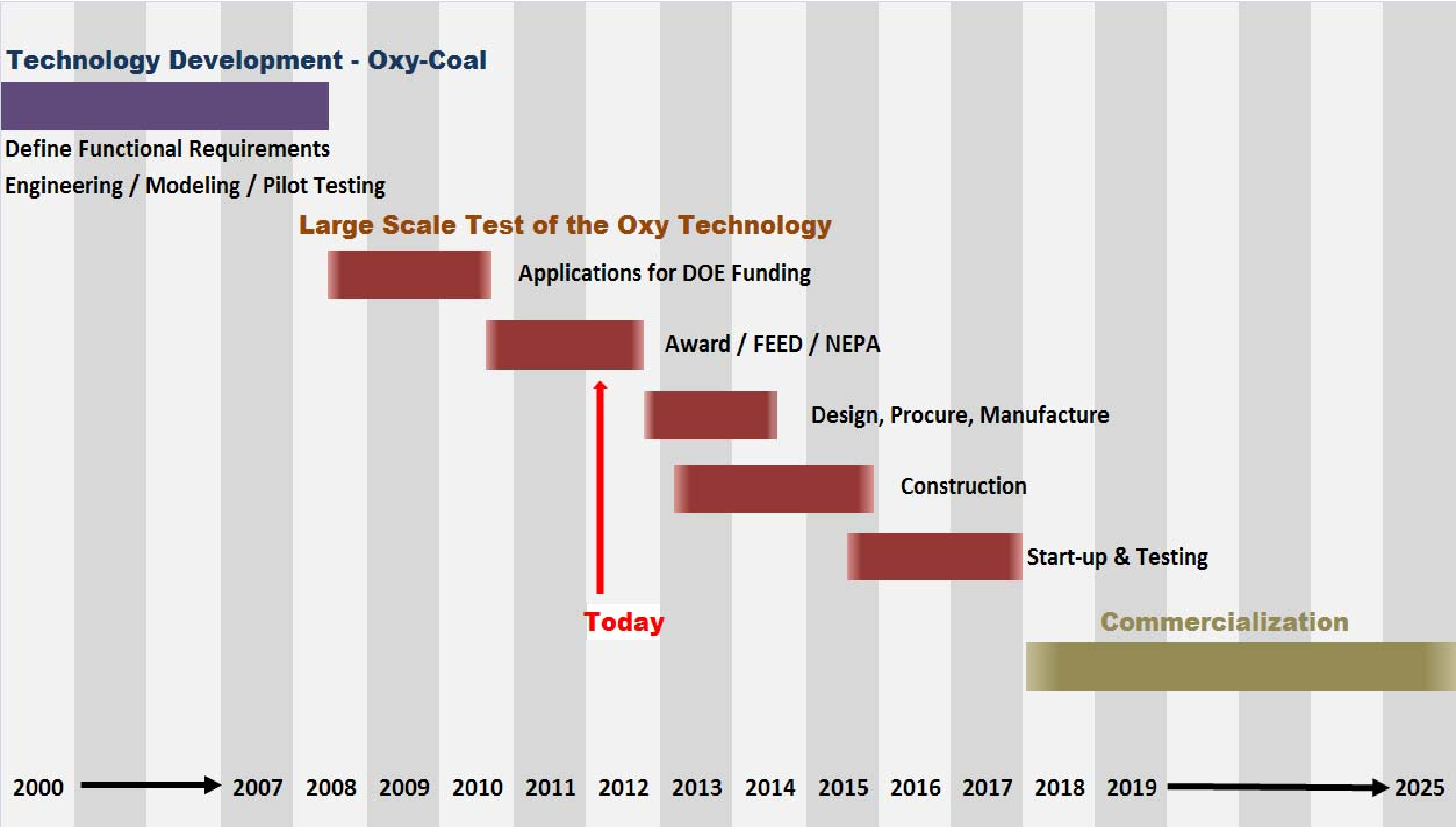


Oxy-combustion

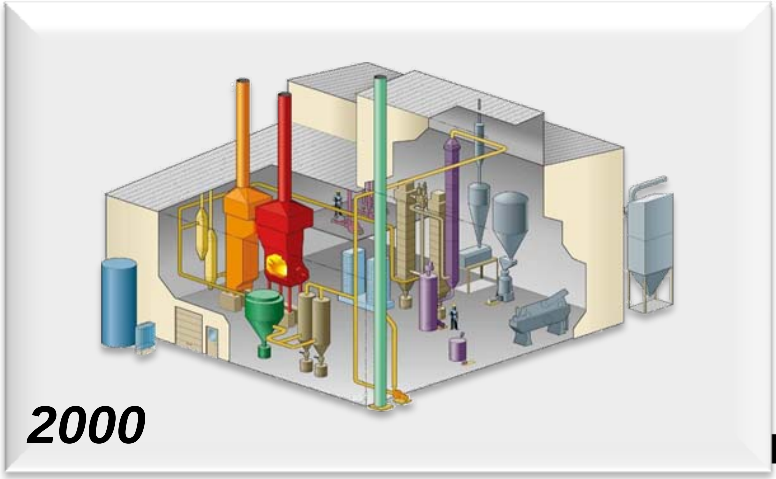
Post-Combustion Capture

clean energy technologies

Oxy-Coal Path to Commercialization

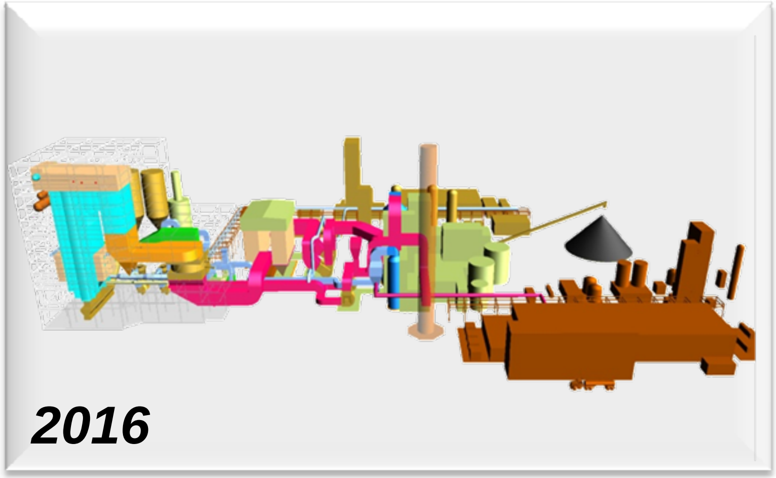


Oxy-combustion Development Path



Small pilot 1.5 MWth

Large pilot 30 MWth



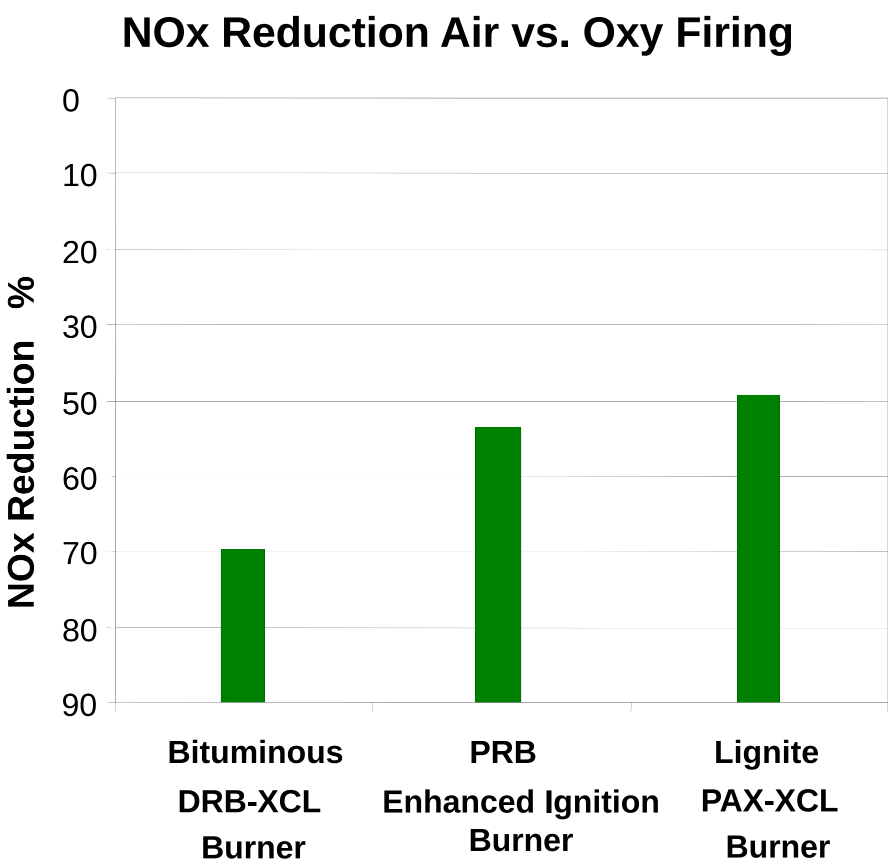
FutureGen 2.0 - 200MWe gross

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*

Combustion Performance

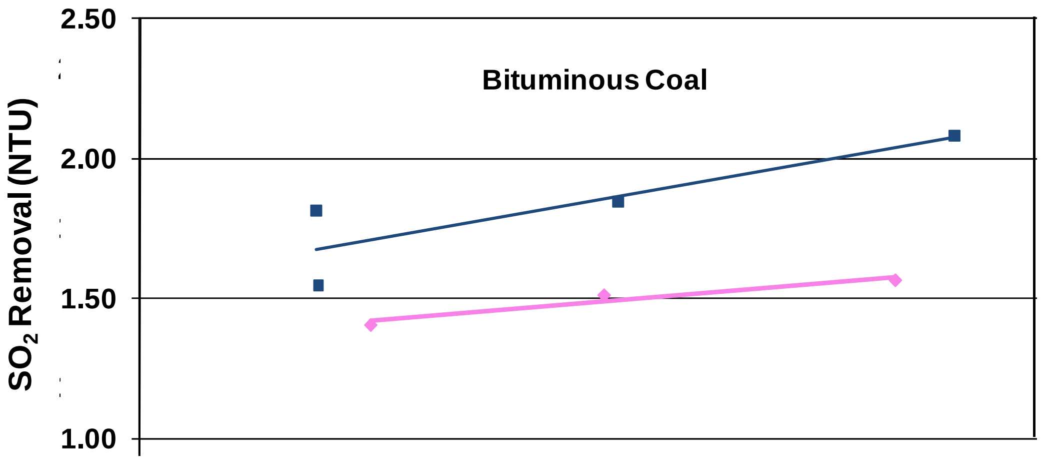
- Significant NOx reduction verified
- CO slightly lower with oxy-combustion
- LOI similar for air or oxy
- Attached stable flames with all fuels



Wet Scrubber Performance

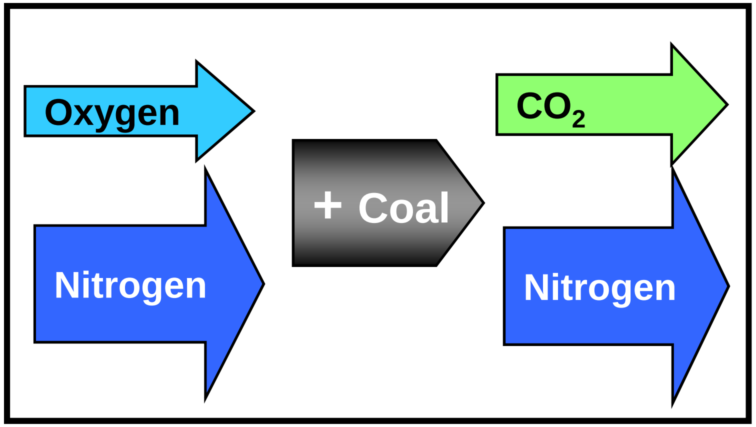
SO_2

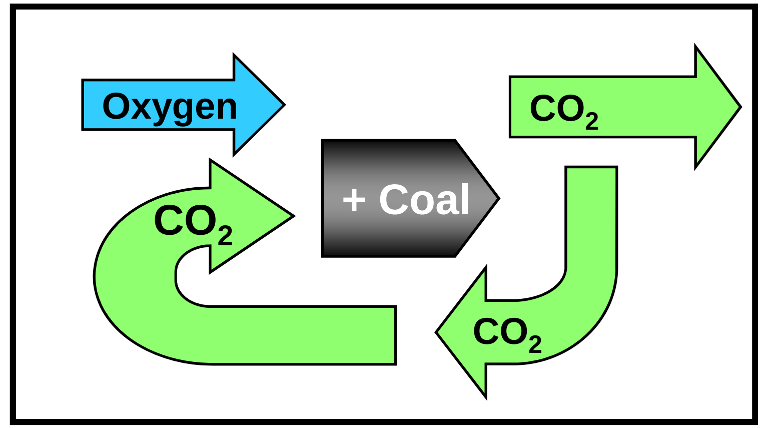
- **Relative performance showed oxy-firing SO_2 removal 5 % to 10 % better than air-firing removal (91.2% to 92 % SO_2 removal)**

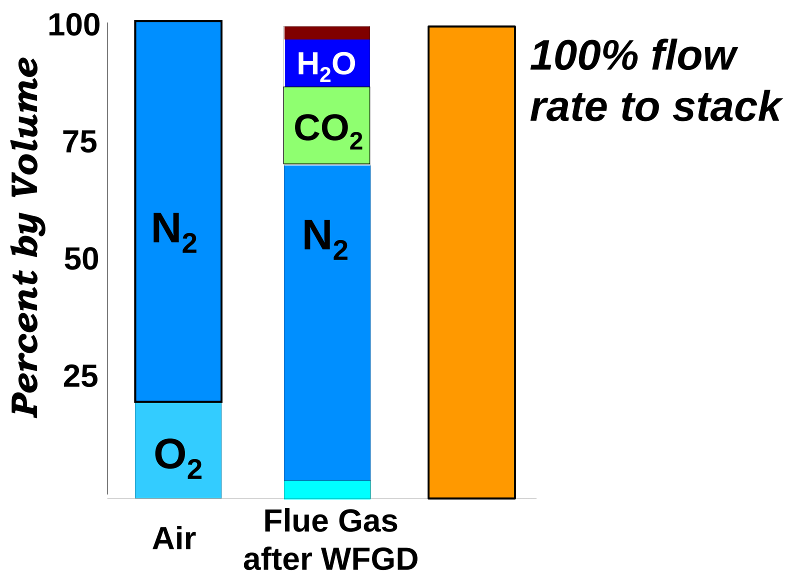


WFGD Tower Installation

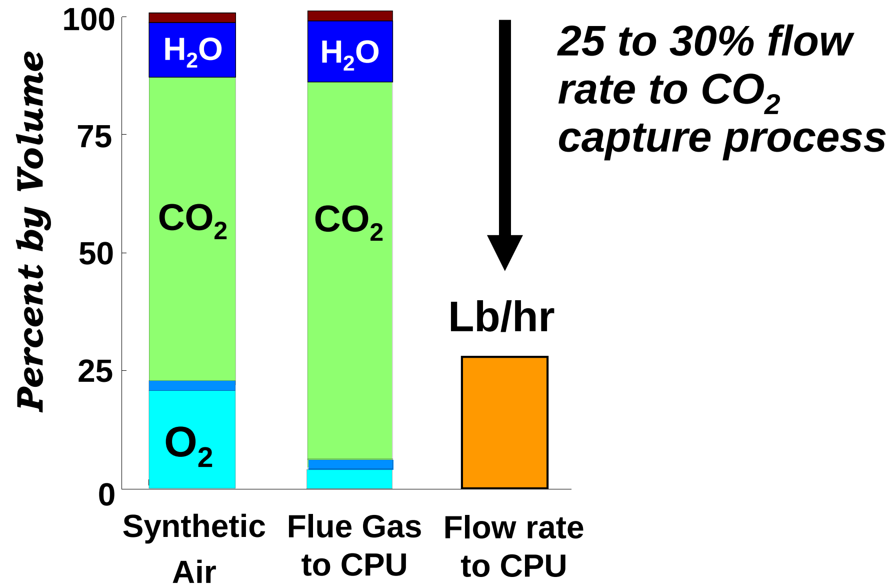
Oxy-Coal Combustion Principles





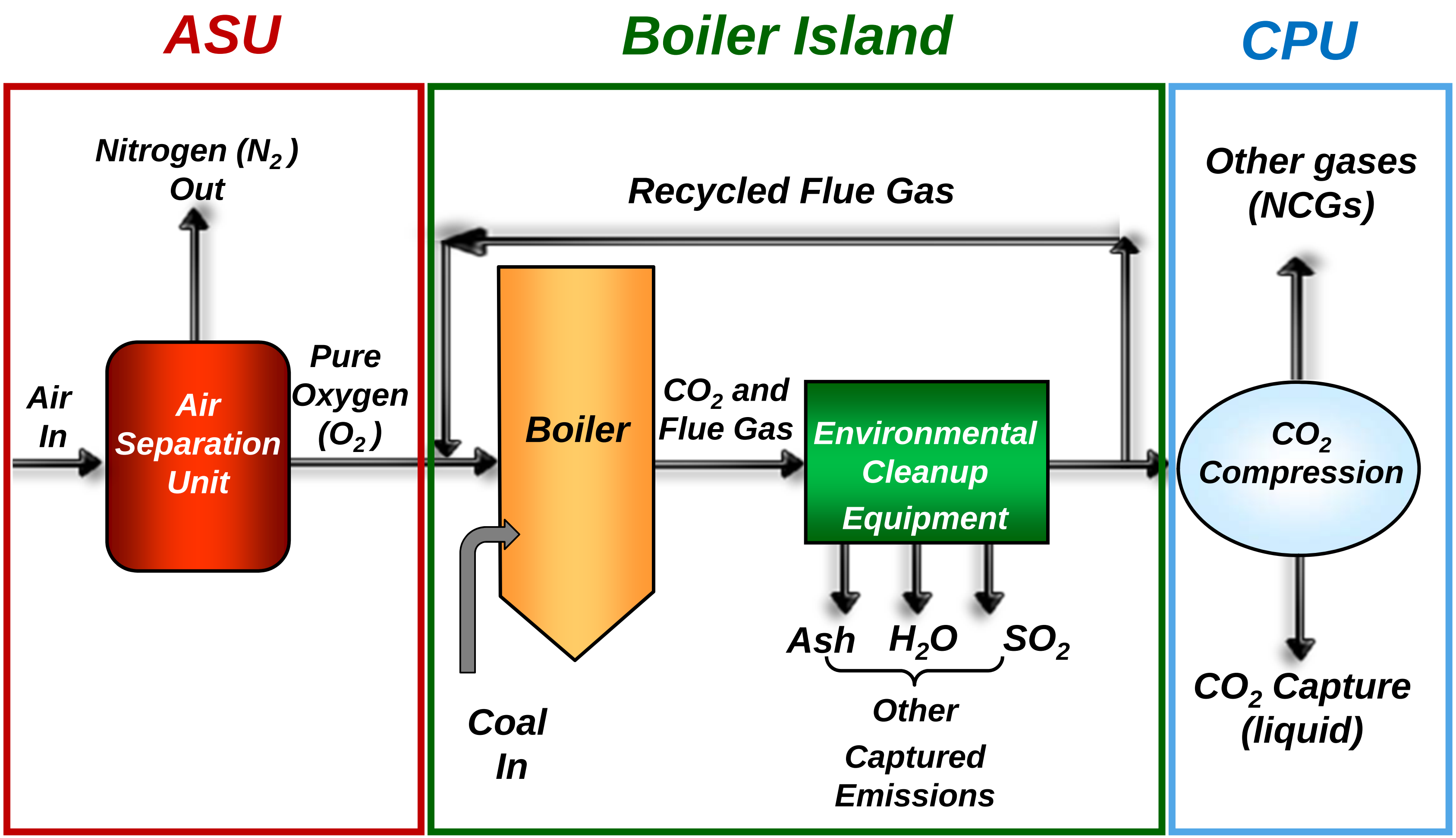


Conventional Combustion



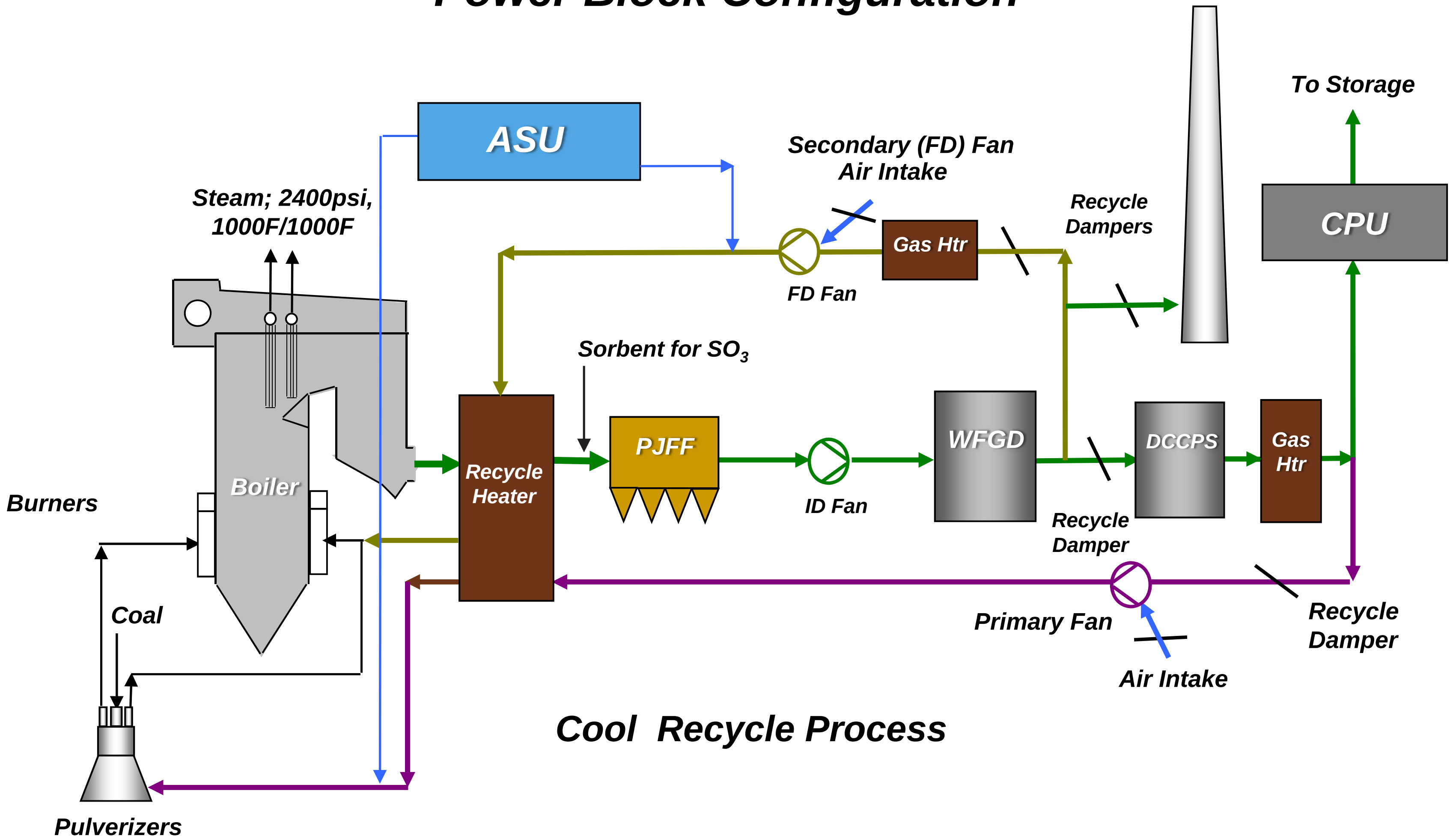
Oxy-Coal Combustion

Oxy-Coal Plant Configuration



FutureGen 2.0
Oxycombustion Carbon Capture Plant

Power Block Configuration



Cool Recycle Process

Future Gen 2.0 Project Participants

Power Generation & CO_2 Capture

CO_2 Transport and Storage

Oxy Project Objectives

Prove the Oxy-combustion process at commercial scale

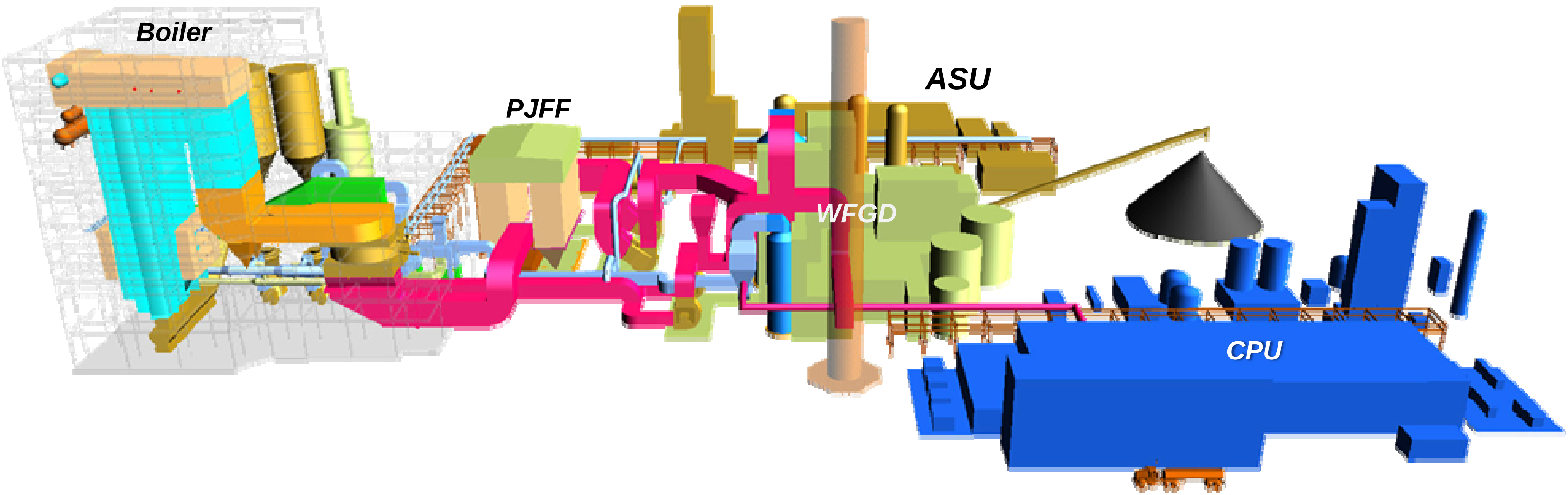
- Establish a cost and schedule baseline for the technology
- Equipment Design Considerations – Primarily Boiler
  - Reliability – component design, materials of construction
  - Maintainability – erosion, corrosion, outage cycles
  - Not designed for high efficiency – designed for flexibility & learning
  - 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

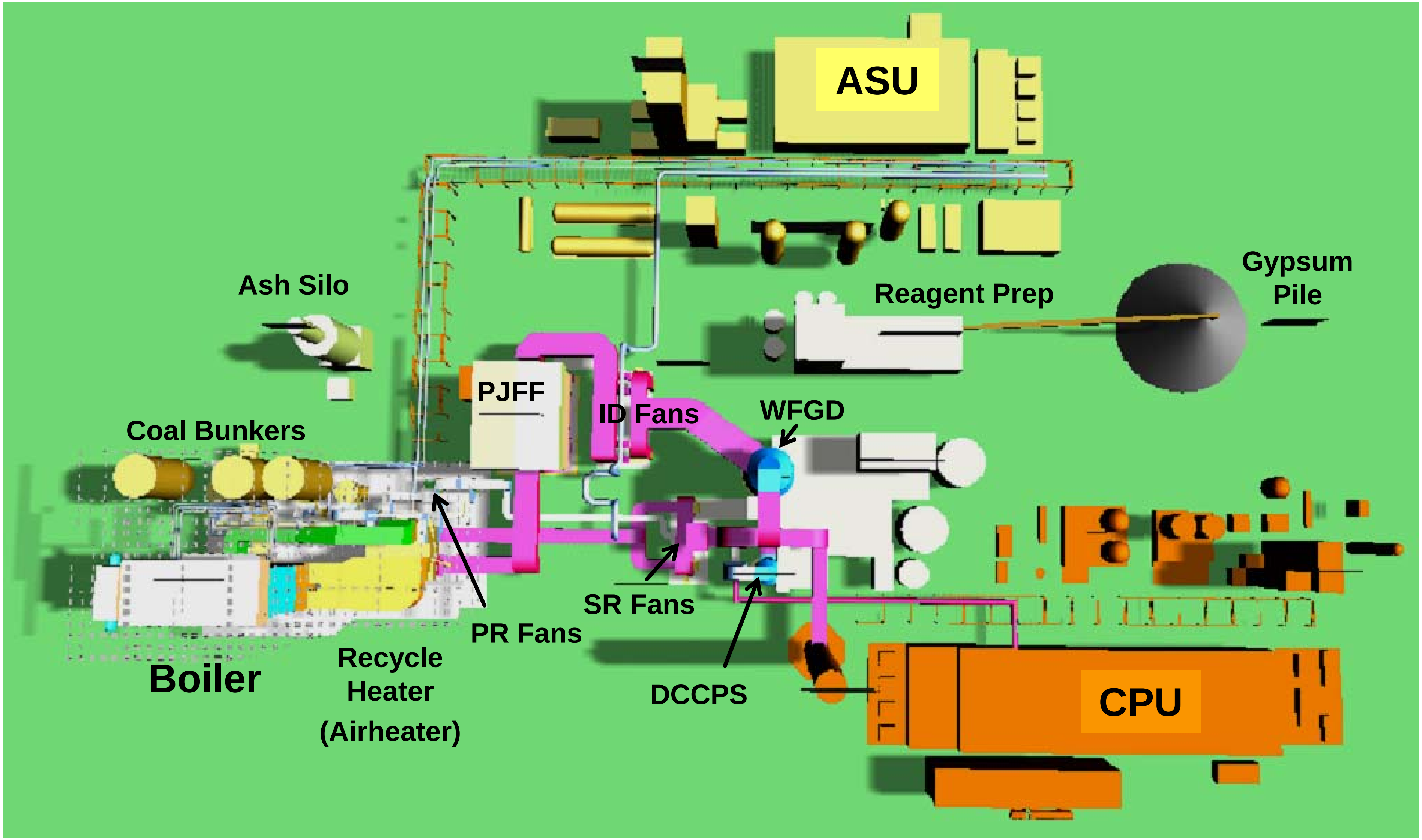
- **Meredosia, IL: Owned by AER**
- **3-coal fired units (2 retired)**
- **Unit 4, 200 MWe oil-fired boiler built in 1975, 2400 psig 1000/1000F Steam Cycle, low operating hours**
- ***3500 TPD CO_2 to Storage***

FG2.0 Oxy-Coal Capture Plant

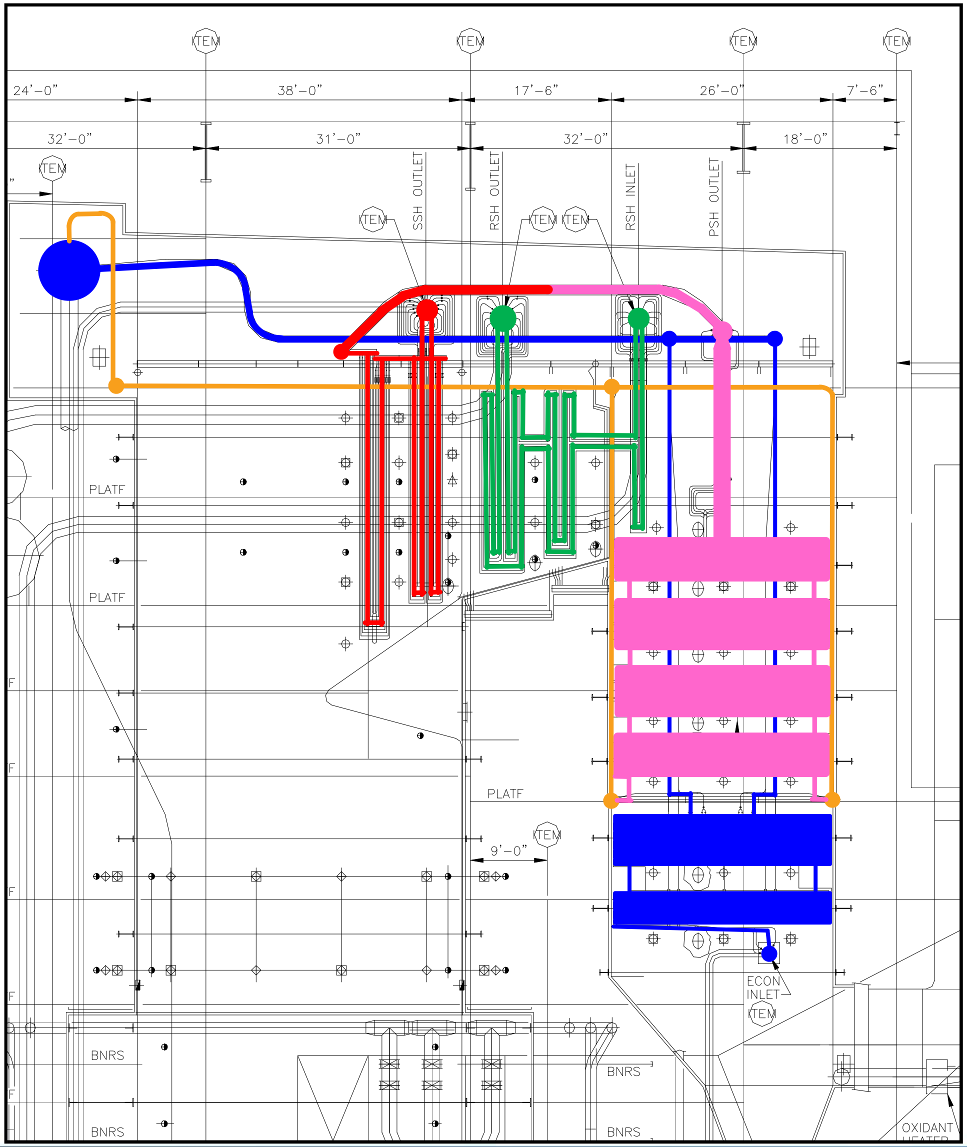


Not the optimal equipment arrangement for a new plant but the best possible in this case due to site space limitations. Will be a common occurrence with existing plant retrofits and repowering

Plant Equipment Layout



Steam & Water Flow Path



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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