# *FutureGen 2.0 Oxy-Coal Carbon Capture and Storage Project*




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# Introduction

# The Babcock & Wilcox Company

***Leading technology innovator in power generation and nuclear components with a legacy spanning more than 140 years***


## Government Operations

- **Supplies components for submarines and aircraft carriers**
- **Provides various other services to U.S. Government, primarily within the nuclear weapons complex of the DOE**

## Power Generation Systems

- **Designs, engineers, manufactures and constructs large utility and industrial power generation systems**
- **Supplies fossil-fired boilers, commercial nuclear steam generators and components, and environmental equipment and related aftermarket parts and services**

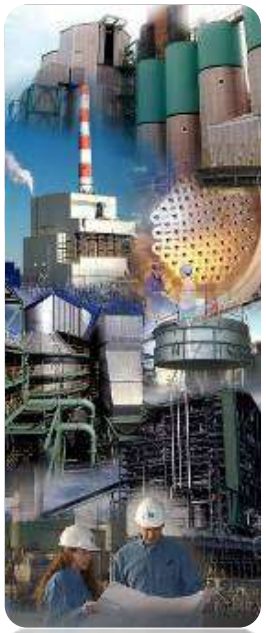
# Power Generation – Fossil and Renewables

## Global Reach


Total Employees: ~ 8,700
Including JV employees

- Installed 38% of boilers in North American coal-fired power plants
- Supplied worldwide capacity of more than 300,000 MW in 800+ utilities in 90+ countries
- Manage operations and maintenance of North America power facilities

## Product Line Portfolio



- Traditional Power
  - Steam Generation
  - Service and O&M (Operation & Maintenance)
  - Construction and EPC (Engineer-Procure-Construct)
  - Boiler Cleaning and Material Handling
- Clean Coal
  - Environmental Systems and Service
  - $SO_2$, NOx, Carbon, Mercury. PM
- Renewables
  - Biomass
  - Solar
  - Energy-from-Waste
  - Auxiliaries

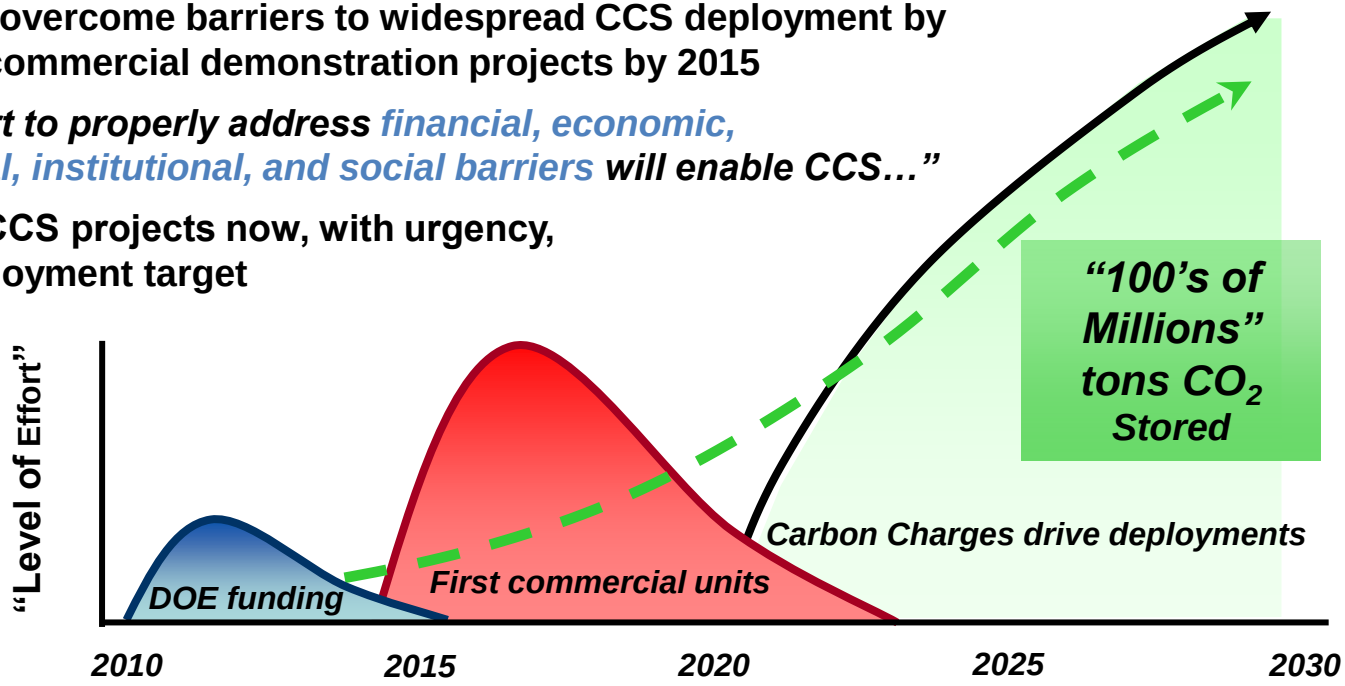
# The CCS Imperative – Deploy Now to Meet 2020 Imperative

## FutureGen 2.0 Project

- 200 MWe coal-fired carbon capture and geologic storage project, in cooperation with the FutureGen Alliance, largely funded by the DOE
- Will employ Oxy-coal technology; studies/pilots confirm higher efficiency, lower emissions, lower overall cost
- High value to future of Illinois coal and power industries

## Addressing Coal

- Interagency Task Force on Carbon Capture and Storage (released August 2010)
  - Propose a plan to overcome barriers to widespread CCS deployment by 2020, with 5 to 10 commercial demonstration projects by 2015
  - *" A concerted effort to properly address financial, economic, technological, legal, institutional, and social barriers will enable CCS…"*
- Must launch "at scale" CCS projects now, with urgency, to reach DOE 2020 deployment target




Source: Chart Courtesy of Dr. Jonathon Gibbins, UK

# DOE Large Scale CCS Projects

| Project | Location | Capture Rate (tonnes/yr) | Repository | Start Date |
|---|---|---|---|---|
| *Oxy-Combustion* | | | | |
| FutureGen 2.0 | Meredosia, IL | 1,150,000 | GS | 2015 |
| *Pre-Combustion Capture (IGCC)* | | | | |
| Summit Texas Clean Energy | Odessa, TX | 2,700,000 | EOR | 2014 |
| Southern Company | Kemper County, MS | 1,800,000 | EOR | 2014 |
| Hydrogen Energy California | Kern County, CA | 1,800,000 | EOR/GS | 2016 |
| *Post-Combustion Capture* | | | | |
| Basin Electric | Beulah, ND | 450,000-1,360,000 | EOR/GS | 2014 |
| NRG Energy | Thompsons, TX | 400,000 | EOR | 2015 |
| American Electric Power | New Haven, WV | 1,500,000 | GS | 2015 |
| *Industrial CCS Solicitation* | | | | |
| Leucadia Energy | Lake Charles, LA | 4,000,000 | EOR | 2014 |
| Air Products | Port Arthur, TX | 900,000 | EOR | 2013 |
| Archer Daniels Midland | Decatur, IL | 900,000 | GS | 2014 |

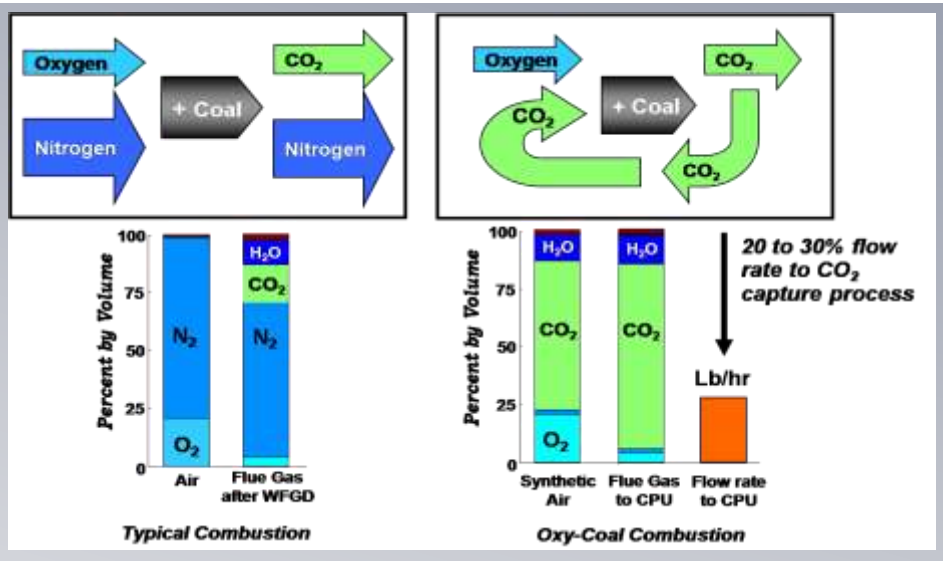
- Foundation for technology competition for new, retrofit and repowering scenarios
- Puts 1st generation commercial CCS technology in place by 2020

# *Oxycombustion*

# NZEP Oxy-Coal Technology

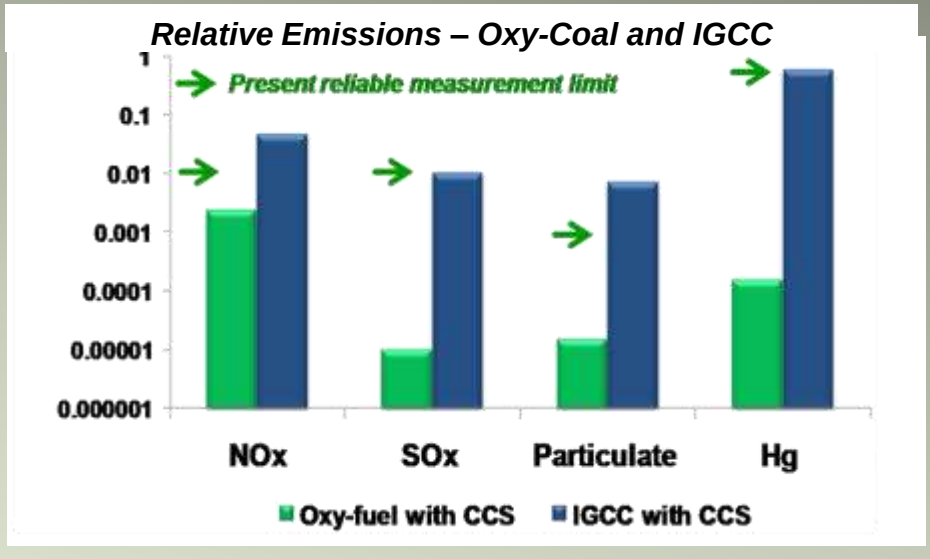
## Oxy-Coal Combustion

- Nitrogen removed from the process
- Flue gas contains carbon dioxide and water (plus remnant emissions)
- Environmental control equipment cleans remnant emissions with remainder removed by CPU



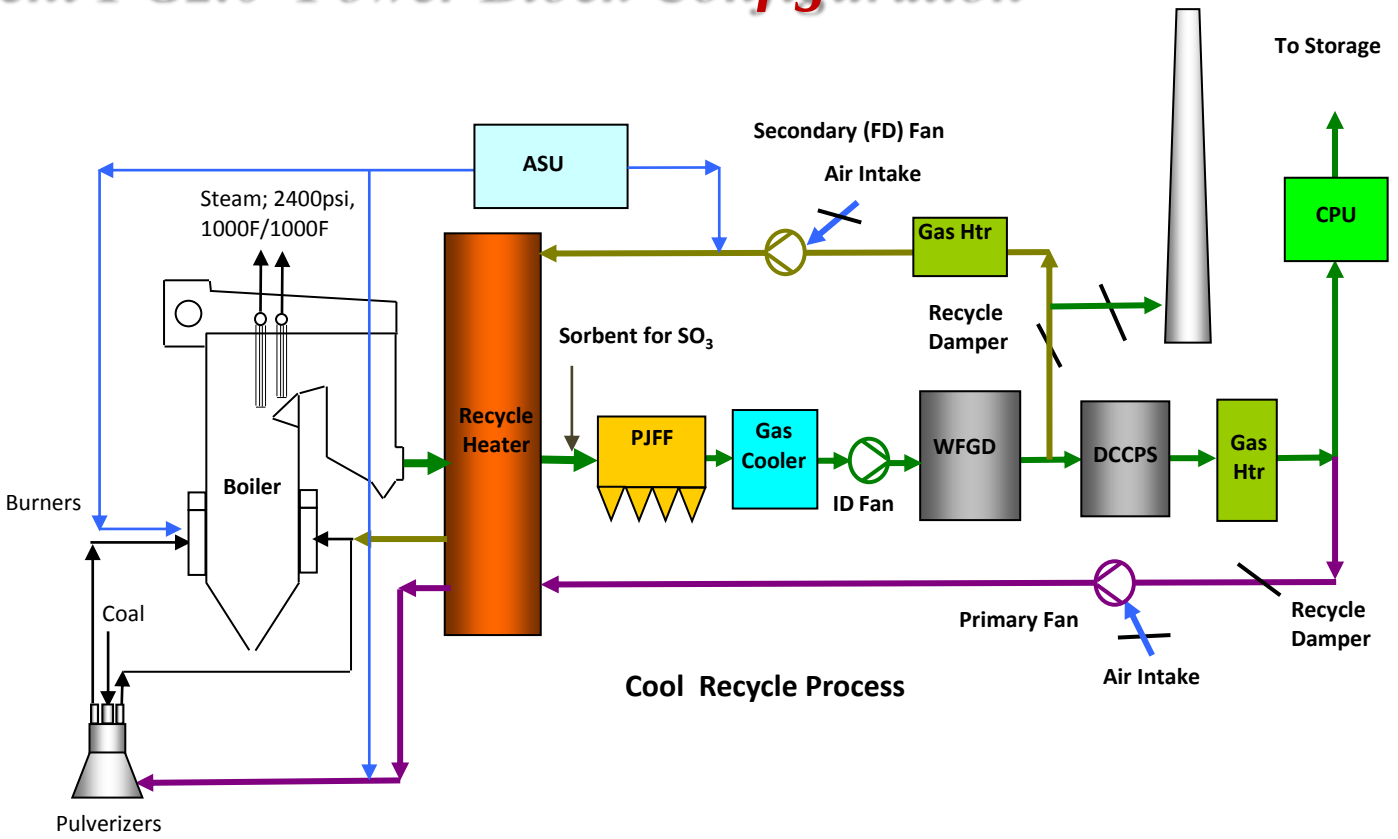

## Near Zero Emission Plant (NZEP) Design

- Oxy combustion provides integrated emissions control for entire flue gas stream
- Oxy-Coal emissions predicted to be lower by several orders of magnitude

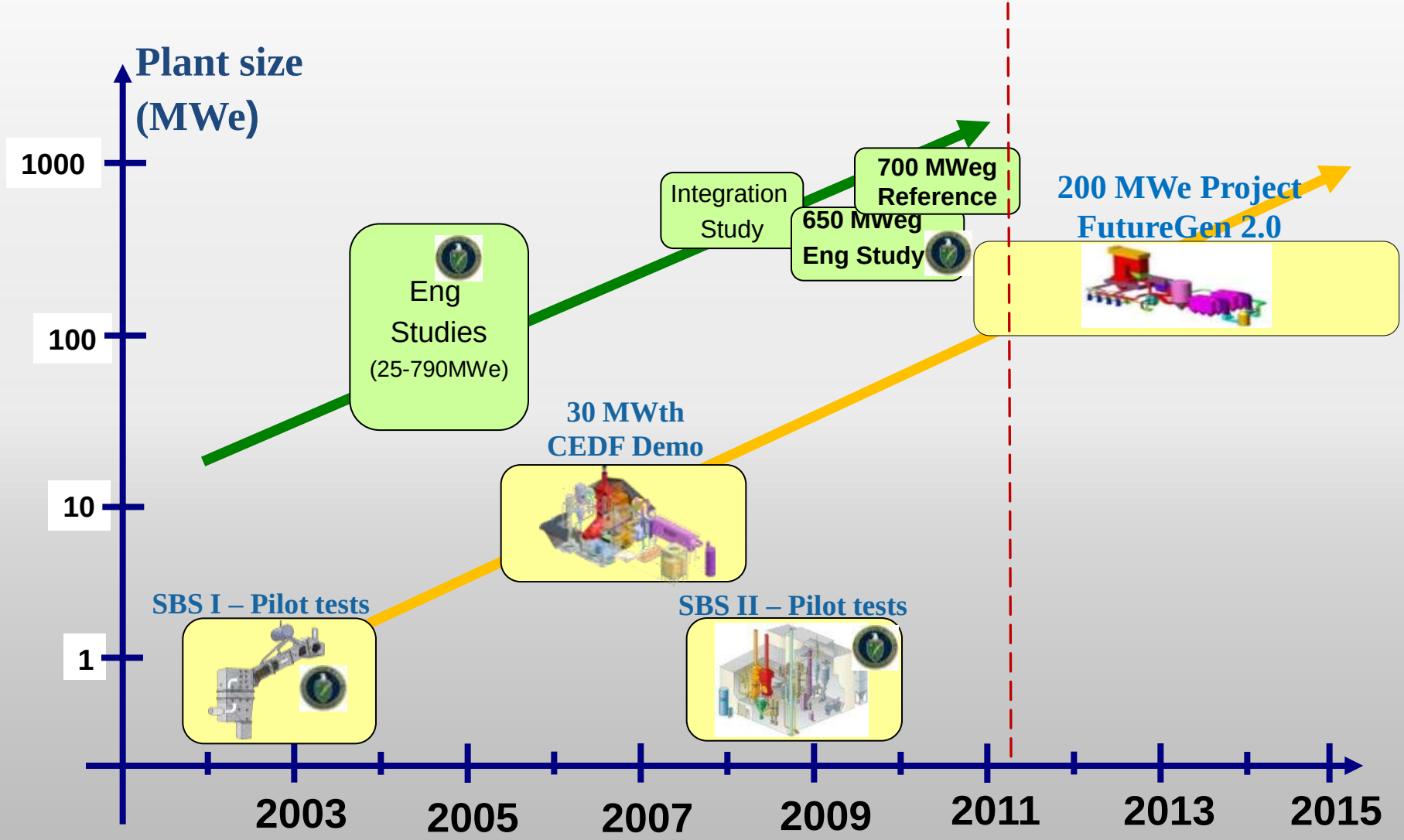


# FutureGen 2.0
# Oxycombustion Carbon Capture Plant

## Current FG2.0 Power Block Configuration



# B&W Oxy-Coal Combustion R&D Summary



# Clean Environment Development Facility (CEDF)

## Original Facility

- Large scale pilot plant for combustion and emission testing (30 $MW_{th}$)
- Low NOx burner development and HAPS testing

**Commissioned in 1994**

**Accomplishments:**

- Developed XCL, XCL –HV and 4S coal burners
- Confirmed HAPS formation and fate
- Developed AireJet burner; first burner fully CFD developed and designed: without small scale pilot plant testing

## Oxy-Combustion Facility

- Tests conducted during Fall 2007 and Spring 2008
- Three fuels: bituminous, sub-bituminous and lignite
- "Wet" burner tests conducted in Summer 2008

**2007 thru 2008**

**Accomplishments:**

- Combustion, Burner and Pulverizer Operation
- Boiler heat transfer characteristics
- Oxygen injection system
- Controls - air/oxygen, combustion, safety/interlocks
- Low $NO_x$ operation w/o SCR
- FGD and ESP operating performance
- Flue gas moisture removal
- Forced oxidation of wet FGD slurry
- Ability to meet flue gas spec to CPU

**Today**

CEDF Facility

# *Oxy-Coal Reference Plant*

**Coal:** PRB, 8400 Btu/lb

**Steam:** 3500 psi, 1100F/1100F

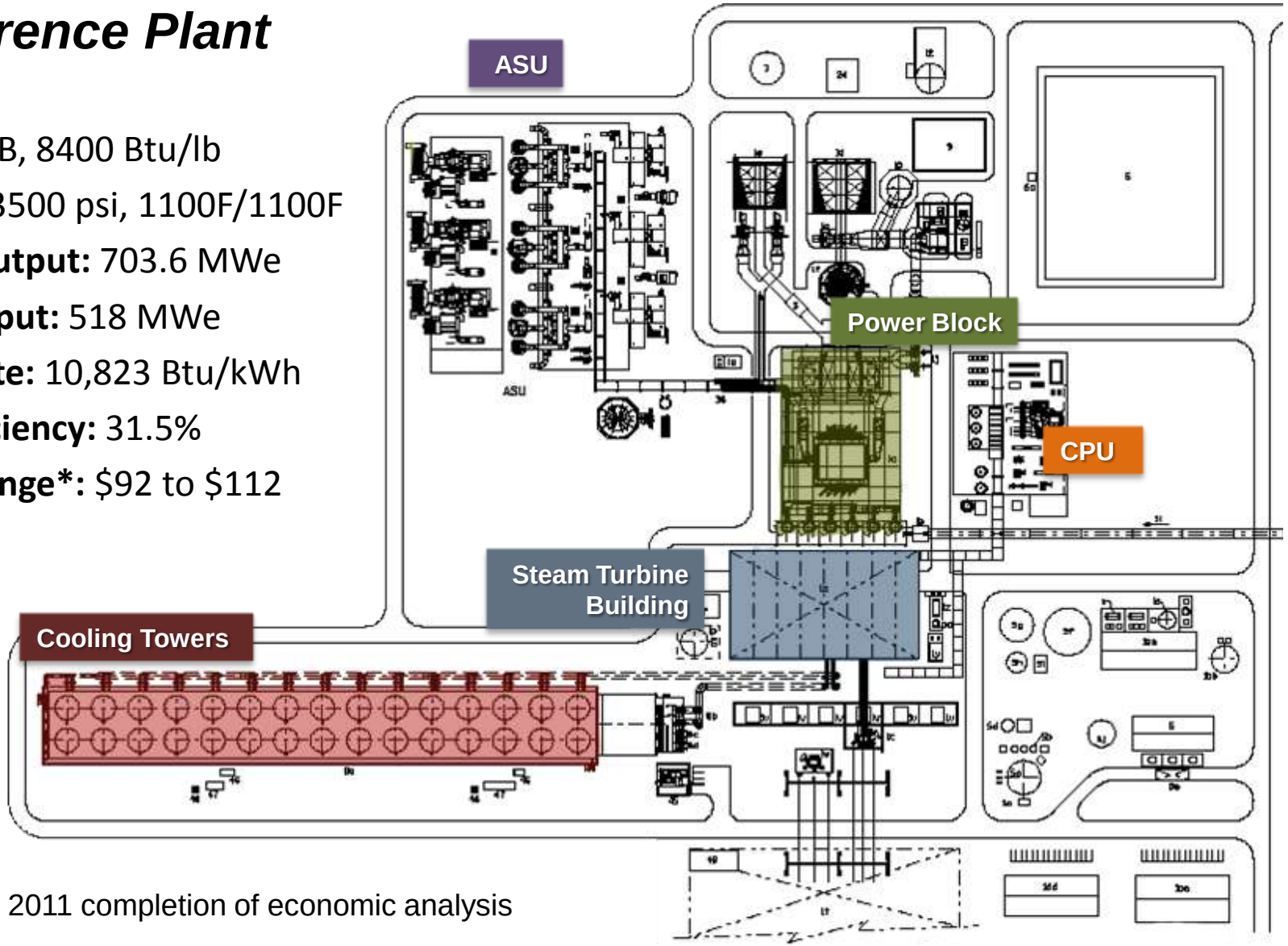
**Gross Output:** 703.6 MWe

**Net Output:** 518 MWe

**Heat Rate:** 10,823 Btu/kWh

**Net Efficiency:** 31.5%

**LCOE Range*:** $92 to $112




* Spring 2011 completion of economic analysis

# Benefits of Oxy-Coal Combustion

- **DOE-NETL studies show oxy-combustion has the potential to be the highest efficiency and lowest cost $CO_2$ capture technology for coal fired plants***
- **Completes DOE programmatic goals of demonstrating future clean coal technologies**
- **Near Zero Emissions of criteria air pollutants (NZEP)**
- **>90% $CO_2$ capture at pipeline quality and purity specifications**
- **U.S.-developed technology for $CO_2$ Capture from coal combustion**
- **Low technology risk – plant components are primarily conventional equipment modified for operation in the oxy-mode. An oxy-plant will look and operate like a conventional power plant.**
- **B&W and Air Liquide America have led oxy-combustion development since 2001- both are experienced technology providers with a long history of successful large scale project execution**

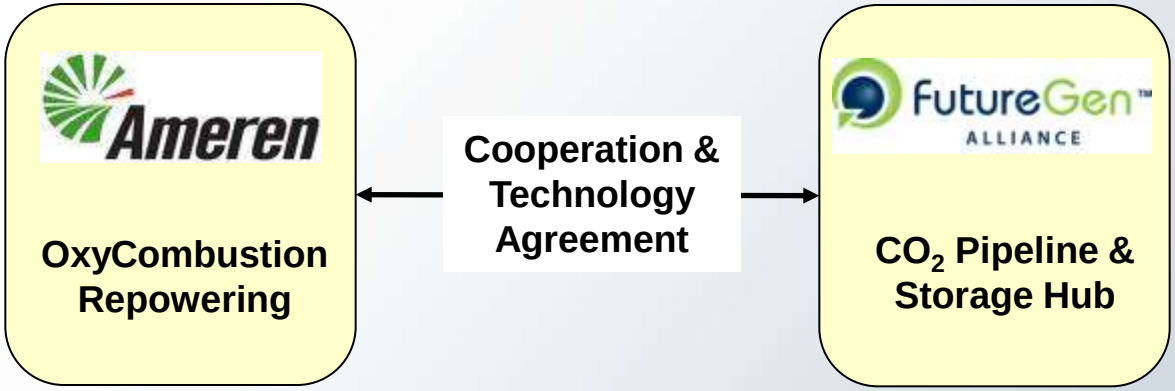
* DOE/NETL 2007-1291 Rev. 2, August 2008, "Pulverized Coal Oxy-combustion Power plants"
DOE/NETL 2007-1281 Rev.1, August 2007 "Cost and Performance Baseline for Fossil Energy Plants"

# *Future Gen 2.0*
# *200 MWe Oxycombustion*

*Project Structure*

# Project Organizational Structure


Project Oversight




Project Management & Execution

# FutureGen 2.0 – Oxy-Combustion Project

## Meredosia Power Station

- Meredosia, IL: Owned/operated by AER
- 3-coal fired units (2 retired)
- Unit 4, 200 MWe oil-fired built in 1975
- 160Bar / 540C / 540C

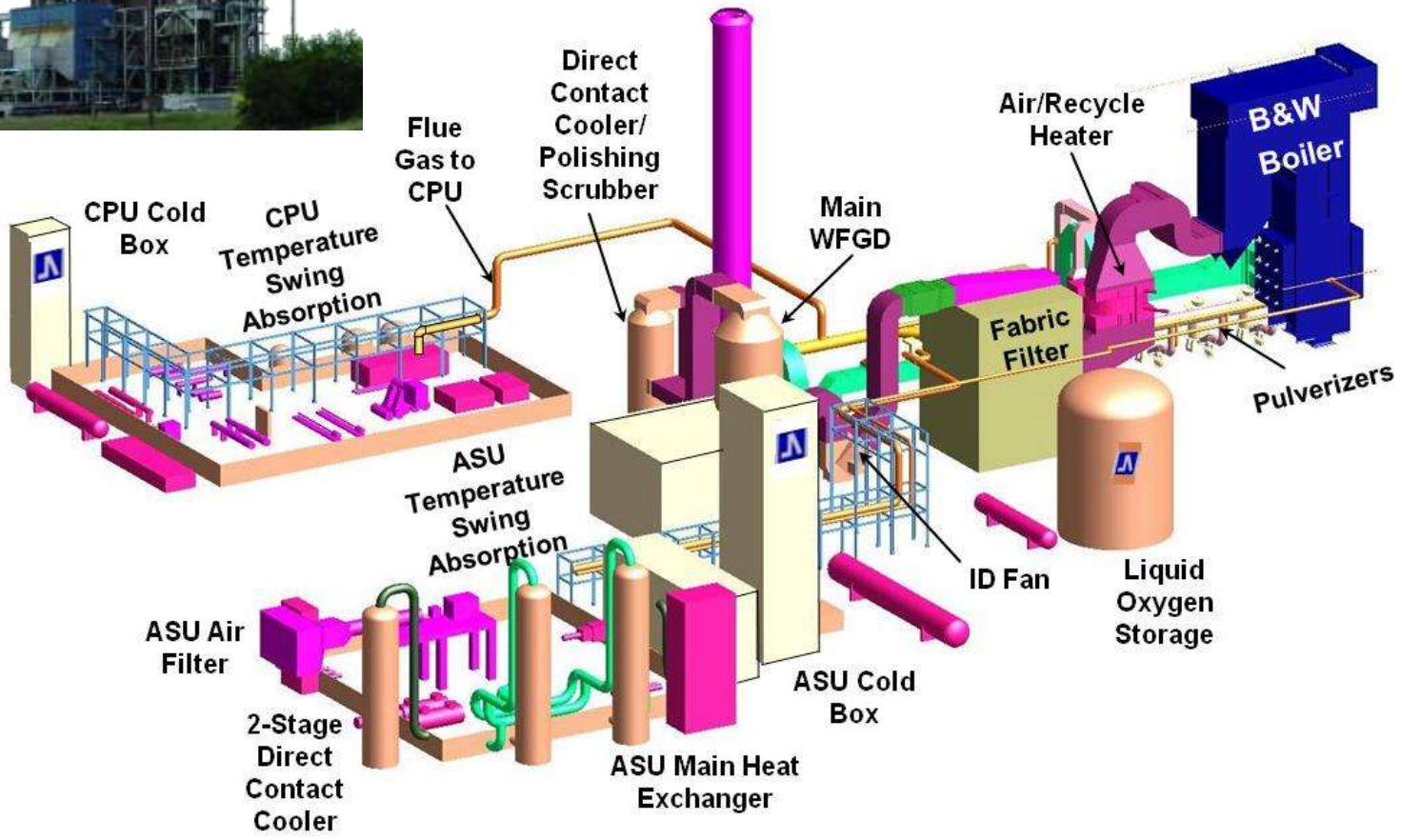
## Project Structure

- Capture – Ameren Energy Resources (AER), teamed with B&W
- Transport & Storage – FutureGen Industrial Alliance
- Repower Unit 4 steam turbine
- Purpose-built Oxy-PC boiler
- Coal variations to be evaluated
- $1.3B Investment w/ US-DOE

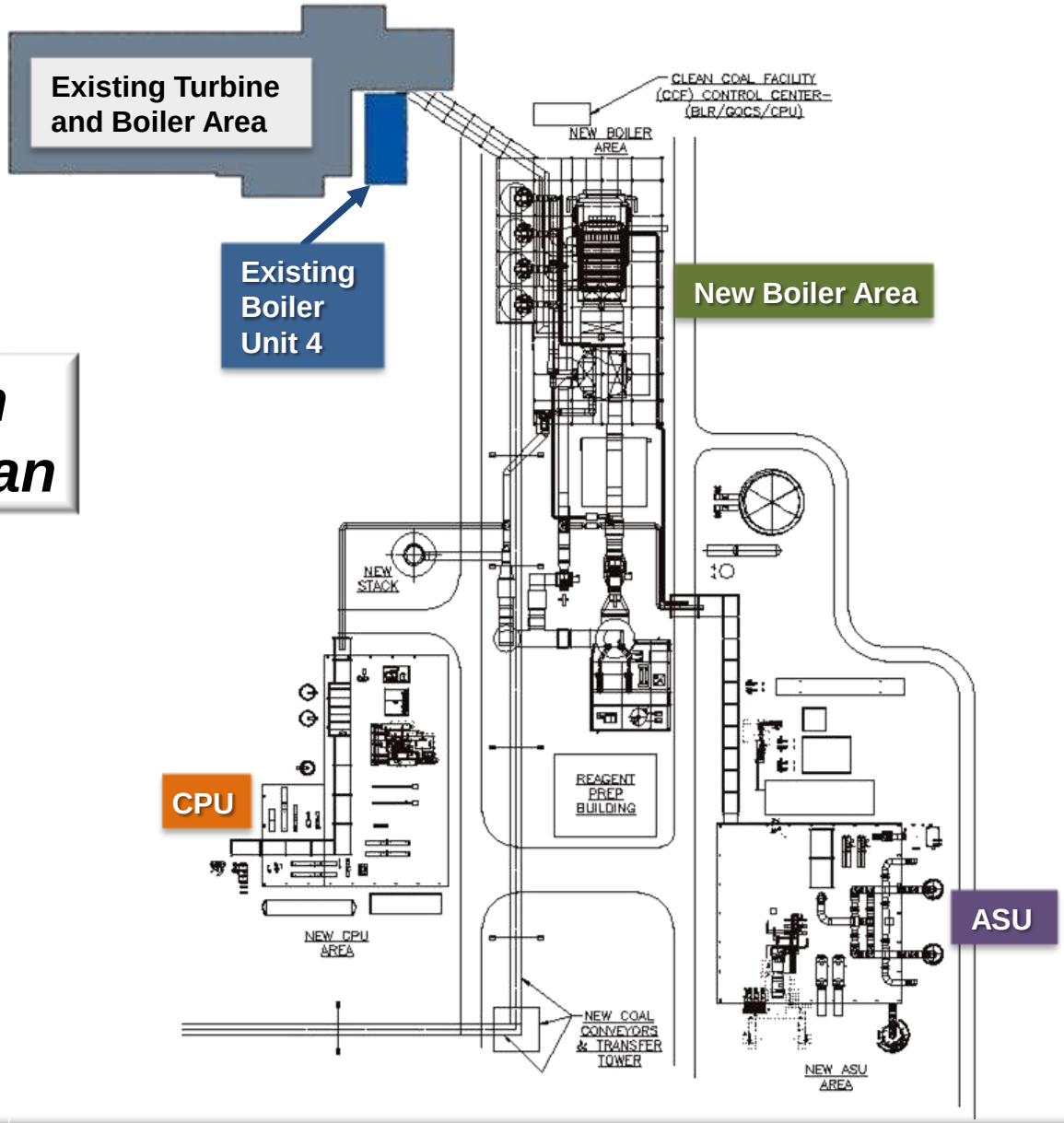
## Project Timeline

- Project awarded Sept. 29, 2010
- FEED and NEPA complete 2012
- “Ready to test,” early 2016
- Transport/Storage solicitation in progress

# *FutureGen 2.0 Clean Coal Plant*



# *FutureGen 2.0 Site Plan*



## *Project Structure*

# Alliance's International Participation

Alpha Natural Resources

ANGLO AMERICAN

bhpbilliton

CONSOL ENERGY

FutureGen ALLIANCE

**International Industrial Participation**

e·on U.S.

CATERPILLAR®
(Intention Announced)

Exelon
(Intention Announced)

xstrata

Peabody

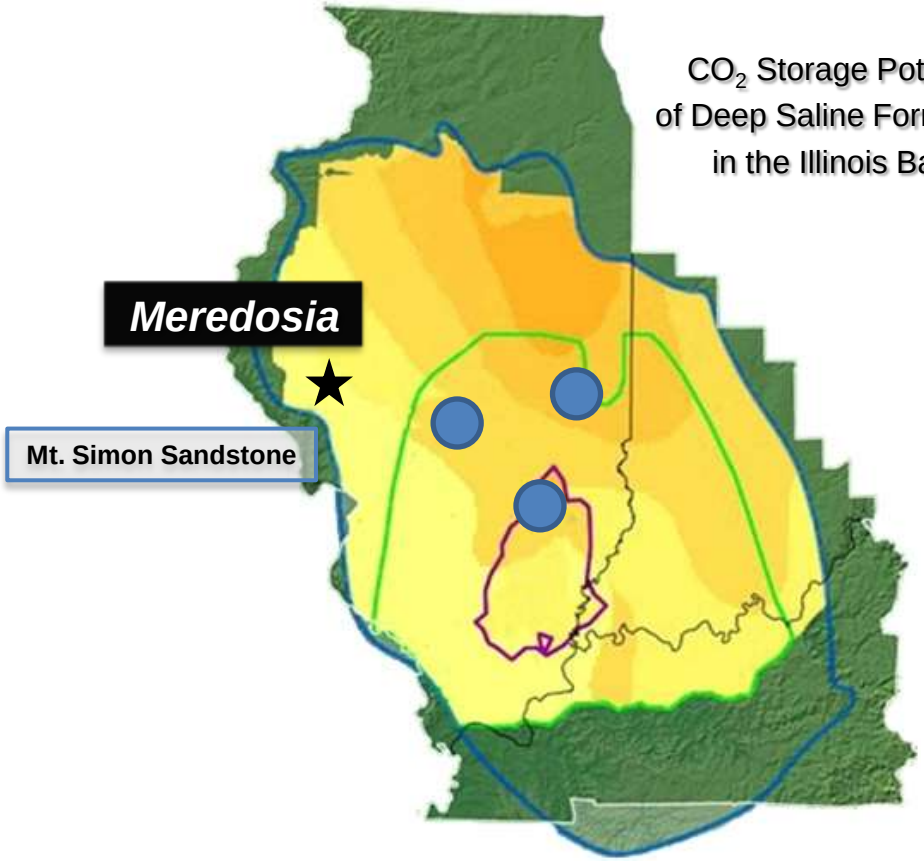
RIO TINTO ENERGY AMERICA

## *Project Structure*

# Alliance Background

- Formed in 2005 as a non-profit organization with a mission of advancing clean coal technology in partnership with the U.S. Department of Energy
- Non-profit consortium of coal production companies, coal trading companies, mining equipment suppliers and coal-fueled utilities
- Alliance is expanding it membership
- Balance of the funding is derived from:
  - U.S. Department of Energy
  - Power purchase agreement with associated $CO_2$ services agreement
  - Modest Financing

# Potential $CO_2$ Storage Resource




$CO_2$ Storage Potential of Deep Saline Formations in the Illinois Basin

**Metric tons per km2**

**High: 1,700,000**

**Low: 140,000**

***Total Potential:***
***29 to 117 billion metric tons***

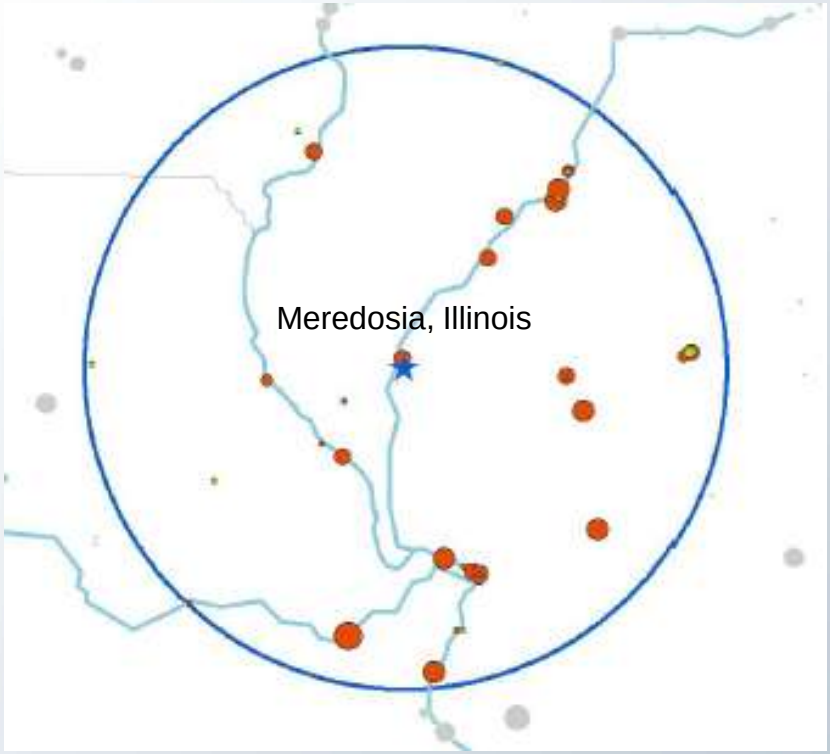
## *Enabling Regulatory Environment*

- **Clean Coal Portfolio Standard Law**
- **Clean Coal FutureGen for Illinois Act**
- **NEPA/EIS experience and success by FutureGen Alliance**
- **State of Illinois Coal Development and Research Programs**
- **Subsurface rights defined, significant resource development history**

## *Project Description*

# $CO_2$ Pipeline and Storage Hub

- Develop a deep saline regional storage facility that would sequester $CO_2$ from Meredosia and other sources
- The concept of $CO_2$ hubs is not new
  - Included is Australian CCS Roadmap
  - Common in European discussions
  - $CO_2$ pipeline networks used in enhanced oil recovery applications
- Multiple major $CO_2$ sources within 100+ miles of Meredosia

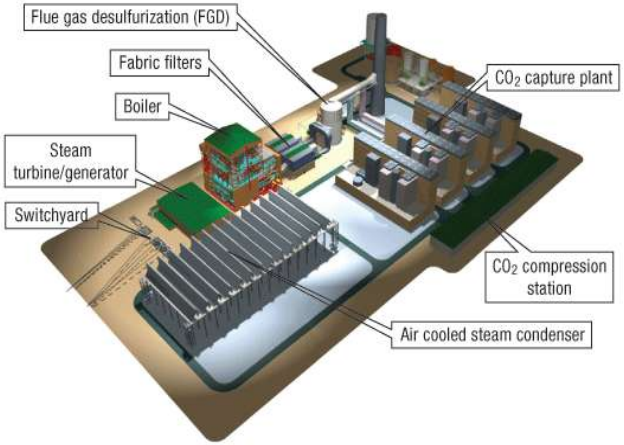


# *Post-Combustion Capture*

# *Post Combustion Capture (PCC) for $CO_2$*

- Partial capture solutions considered essential for creating options for existing fleet transition to reduced $CO_2$ emissions
- RSAT solvent tests at National Carbon Capture Center
- Advanced solid sorbents and solvents program

**B&W Reference Plant**




**Tenaska, Trailblazer Project**

**Advanced Capture**

U.S. Department of Energy

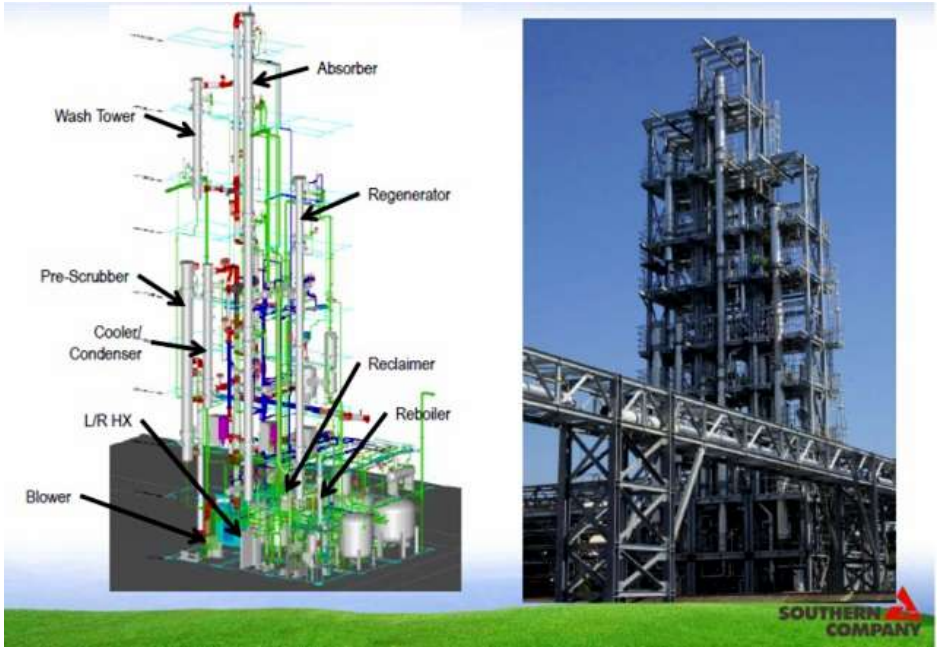
# National Carbon Capture Center

at the Power Systems Development Facility

PARTICIPANTS:

NETL, Southern Company, EPRI, AEP American Electric Power, Luminant, Peabody, ACI Arch Coal, Inc., RioTinto, NRG

Managed by Southern Company Services, Inc.



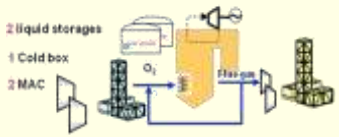

- **- NCCC is the DOE supported post combustion capture test center with multiple test units using flue gas from operating boiler at SoCo Plant Gaston**
- **- B&W won competition to be first to test in Pilot Solvent Test Unit, ~10 tpd pilot plant that is full "replica" of deployable system – the key next step**
- **- Testing to be completed on OptiCap solvent and run for ~90 days to test durability and determine operating characteristics in power plant environment**

# Our Commitment to CCS Innovation Remains Strong

## Oxy-Combustion Innovations

- Target LCOE increase to <35%
- Larger single train ASU
- Advanced USCPC for efficiency to ~39% with CCS

## Oxy-Combustion Adaptive Plant




ASU – 1 x 5100 mtpd
Boiler CPU – 7300 mtpd

- Make LOX off-peak
- Higher output on-peak
- Reduced CAPEX

## Chemical Solvent Evolution

- Reduce energy use 20%
- Optimized and new formulas
- Solvent "enhancers" (e.g., enzymes)
- Market-ready 2015?

## Chemical and Physical Sorbents

- Reduce energy use >>20%?
- Enhanced natural materials
- Man-made molecules
- Market-ready 2020?

# *Thank You*

B&W R&D Facility
Barberton, Ohio