"We are passionate about innovation and technology leadership"

Oxy-Fuel Combustion

Post Combustion

Chemical Looping

Status of B&W Carbon Capture Programs and Technology

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Presentation Outline

1. Current Climate for fossil fuels (NG prices, UMACT, CO_2 rule) and CCS

2. FutureGen 2.0 Update

3. State of B&W CCS programs
   a) Oxycombustion
   b) Post Combustion
   c) Chemical Looping

EPA United States Environmental Protection Agency

“So, if somebody wants to build a coal plant, they can - it’s just that it will bankrupt them.”- Barack Obama 2008

UMACT and CO_2 Rules

The State of CCS Worldwide

Current CCS Projects Worldwide

Largescale Power Plant CCS Projects Worldwide							
USA							
Project Name	**Leader**	**Feedstock**	**Size MW**	**Capture Process**	**CO2 Fate**	**Start-up**	**Location**
TCEP	Summit Power	Coal	400	Pre	EOR	2014	Texas
Trailblazer	Tenaska	Coal	600	Post	EOR	2014	Texas
Kemper County	Southern	Coal	582	Pre	EOR	2014	Mississippi
HECA	SCS	Petcoke	390	Pre	EOR	2014	California
FutureGen 2.0	FutureGen Alliance	Coal	200	Oxy	Saline	2015	Illinois
WA Parish	NRG Energy	Coal	60	Post	EOR	2017	Texas
Sweeny Gasification	ConocoPhillips	Coal	680	Pre	Saline/ EOR	Cancelled	Texas
AEP Mountaineer	AEP	Coal	235	Post	Saline	Cancelled	West Virginia
Taylorville	Tenaska	Coal	602	Pre	Saline	Cancelled	Illinois
Antelope Valley	Basin Electric	Coal	120	Post	EOR	Cancelled	North Dakota
Canada							
Boundary Dam	SaskPower	Coal	110	Post	EOR	2014	Saskatchewan
Project Pioneer	TransAlta	Coal	450	Post	Saline/ EOR	2015	Alberta
Bow City	BCPL	Coal	1000	Post	EOR	2017	Alberta
Belle Plaine	TransCanada	Petcoke	500	Pre	Undecided	Undecided	Saskatchewan

Abbreviations used:

Oxy = Oxyfuel Combustion Capture
Pre = Pre Combustion Capture
Post = Post Co mbustion Capture
EOR = Enhanced Oil Recovery
EGR = Enhanced Gas Recovery

Saline = Saline Formation
Depleted Gas = Depleted Gas Reservoir
Depleted Oil = Depleted Oil Reservoir
TBD = To Be Decided

Date modified April 3, 2012

Source: Carbon Capture & Sequestration Technologies @ MIT

Current CCS Projects Worldwide

Largescale Power Plant CCS Projects Worldwide							
European Union							
Project Name	**Leader**	**Feedstock**	**Size MW**	**Capture Process**	**CO2 Fate**	**Start-up**	**Location**
Longannet	Scottish Power	Coal	300	Post	Saline	Cancelled	UK
Belchatow	PGE	Coal	250-858	Post	Saline	2015	Poland
Ferrybridge	SSE	Coal	500	Post	Depleted Oil	2015	UK
ROAD	E.ON	Coal	250	Post	Saline	2015	Netherlands
Compostilla	ENDESA	Coal	323	Oxy	Saline	2015	Spain
Don Valley Power Project	2Co	Coal	650	Pre	EOR	2015	UK
Magnum	Nuon	Various	1200	Pre	EOR/ EGR	2020	Netherlands
Getica	Turceni Energy	Coal	330	Post	Saline	2015	Germany
Porto Tolle	ENEL	Coal	660	Post	Saline	On hold	Italy
Goldenbergwerk	RWE	Coal	450	Pre	Saline	On hold	Germany
Janschwalde	Vattenfall	Coal	250	Oxy	Saline	Cancelled	Germany
Norway							
Mongstad	Statoil	Gas	350	Post	Saline	2012	Norway
Kårstø	Naturkraft	Gas	420	Post	Saline	Delayed	Norway
Rest of the World							
Daqing	Alstom & Datang	Coal	350 &1000	Oxy	EOR	2015	China
Taiyuan	B&W and SIEG	Coal	350	Oxy	undecided		
GreenGen	GreenGen	Coal	250/400	Pre	Saline	2018	China

Source: Carbon Capture & Sequestration Technologies @ MIT
Taiyuan added

FutureGen 2.0 History

Meredosia Plant

- Awarded $1 billion AARA funding in September 2010
- Illinois Coal (3.2% sulfur)
- Replace oil-fired unit built in 1975 with oxy-process

Initial Project Structure

- Capture – Ameren Energy Resources (AER), teamed with B&W and Air Liquide
- Transport & Storage – FutureGen Alliance

FutureGen 2.0 Project Schedule & Status

Phase I	Phase II	Phase III	Phase IV
Pre-FEED *(Front End Engineering Design)* October 2010 thru June 2012	FEED July 2012 thru December 2013	EPC and Startup January 2014 to June 2017	Test Period July 2017 to March 2020 (monitoring continues until March 2022)

Status

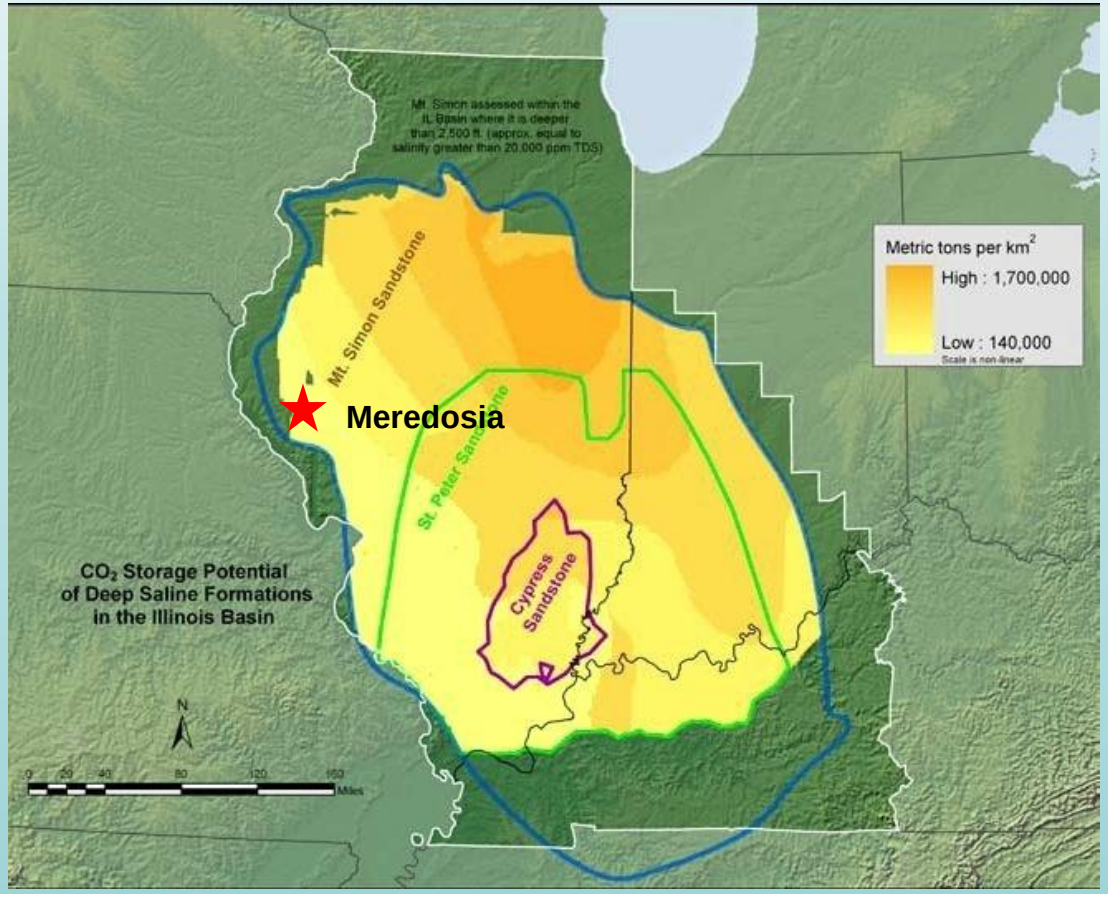
- Phase I is completed and we await approval to begin Phase II.
- Construction air permit submitted to Illinois EPA.
- Midwest Independent System Operator (MISO) interconnection requested.
- The Environmental Impact Statement (EIS) is progressing well
- A draft Power Purchase Agreement (PPA) is pending with the Illinois Power Agency and the Commerce Commission.
- Negotiations to transfer Meredosia unit and the DOE Cooperative from Ameren to the FGIA are underway.

FutureGen 2.0 CO_2 Transport & Storage Plan

FGIA selected Morgan County for storage site

4500 ft Deep Saline Formation (DSF) in Morgan County

(≈32 miles pipeline from the plant)



Reservoir

Potential CO_2 Storage Resource (billion metric tons)

Mt. Simon Sandstone - 27 to 109

State

Potential CO_2 Storage Resource (billion metric tons)

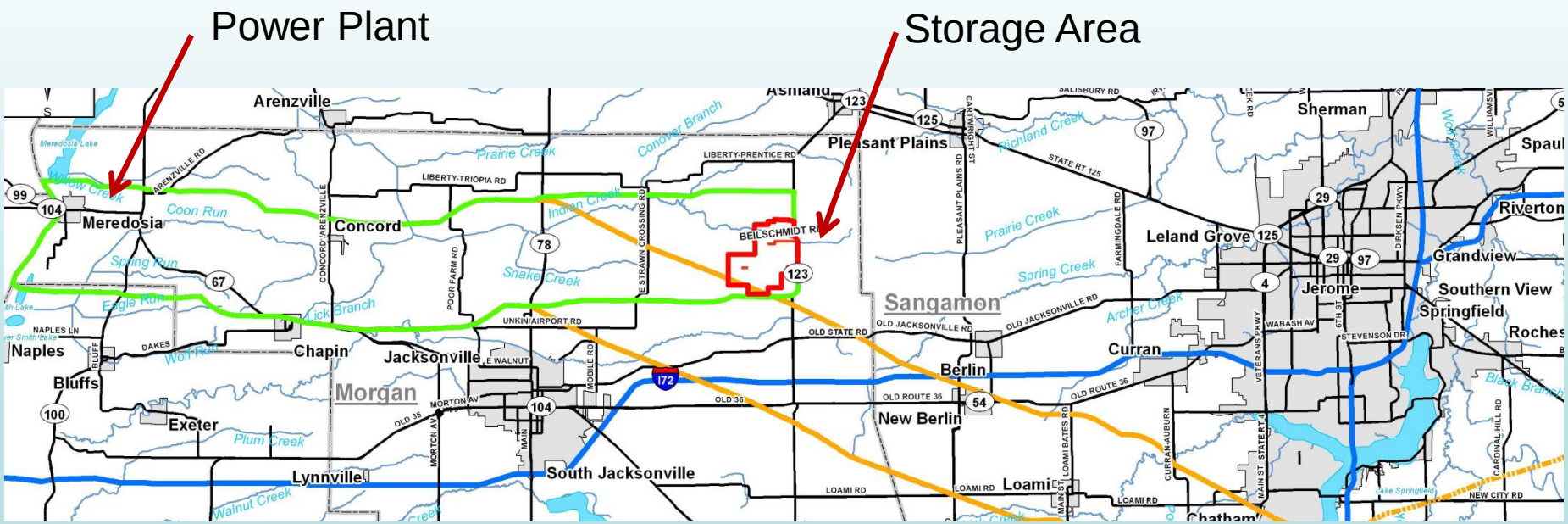
Illinois 20 to 79

Indiana 7.9 to 32

Kentucky 1.5 to 6.3

Total 29 to 117 billion metric tons

FutureGen 2.0 CO_2 Transport & Storage Plan



- **4,812 ft. deep characterization well completed**
- **Data indicates site is suitable for storage**
- **Primary subsurface storage rights secured**
- **Mattoon property sold**
- **Liability management legislation in place**
- **Pipeline routing nearing completion**

FutureGen 2.0 Phase 1 Redesign

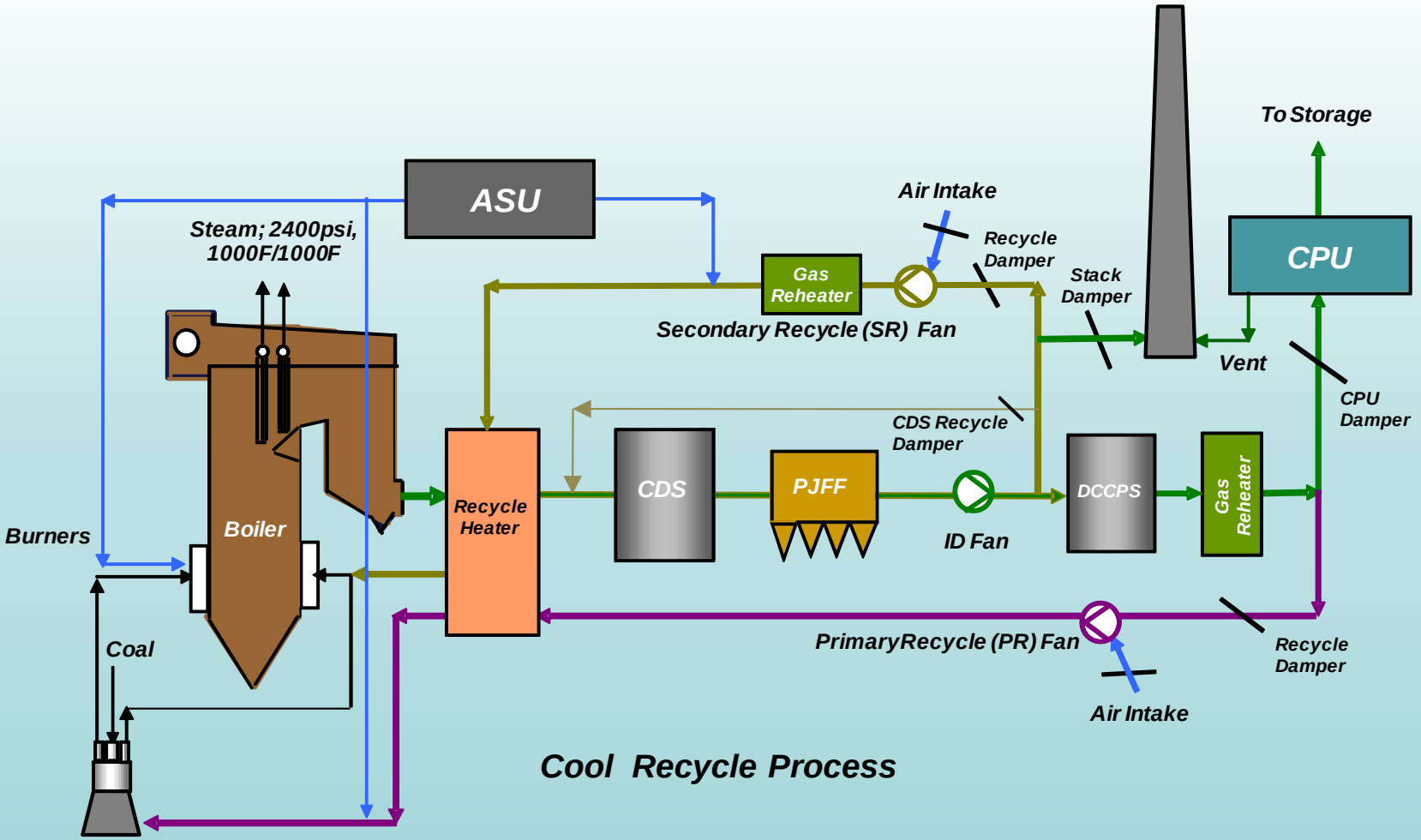
Key Design Basis Changes Implemented:

1. Unit designed for summer rated load of 168 MWe gross (instead of nameplate 203 MWe).
2. Design coal was changed froo 100% Illinois (high S and Cl) to 60% Illinois, 40% PRB blend.

Continuing Requirements:

1. Minimum 90% CO_2 Capture (will actually be > 98%).
2. At least 1 MMT/yr of CO_2 stored (at 85% CF).

FutureGen 2.0 Revised Process Schematic

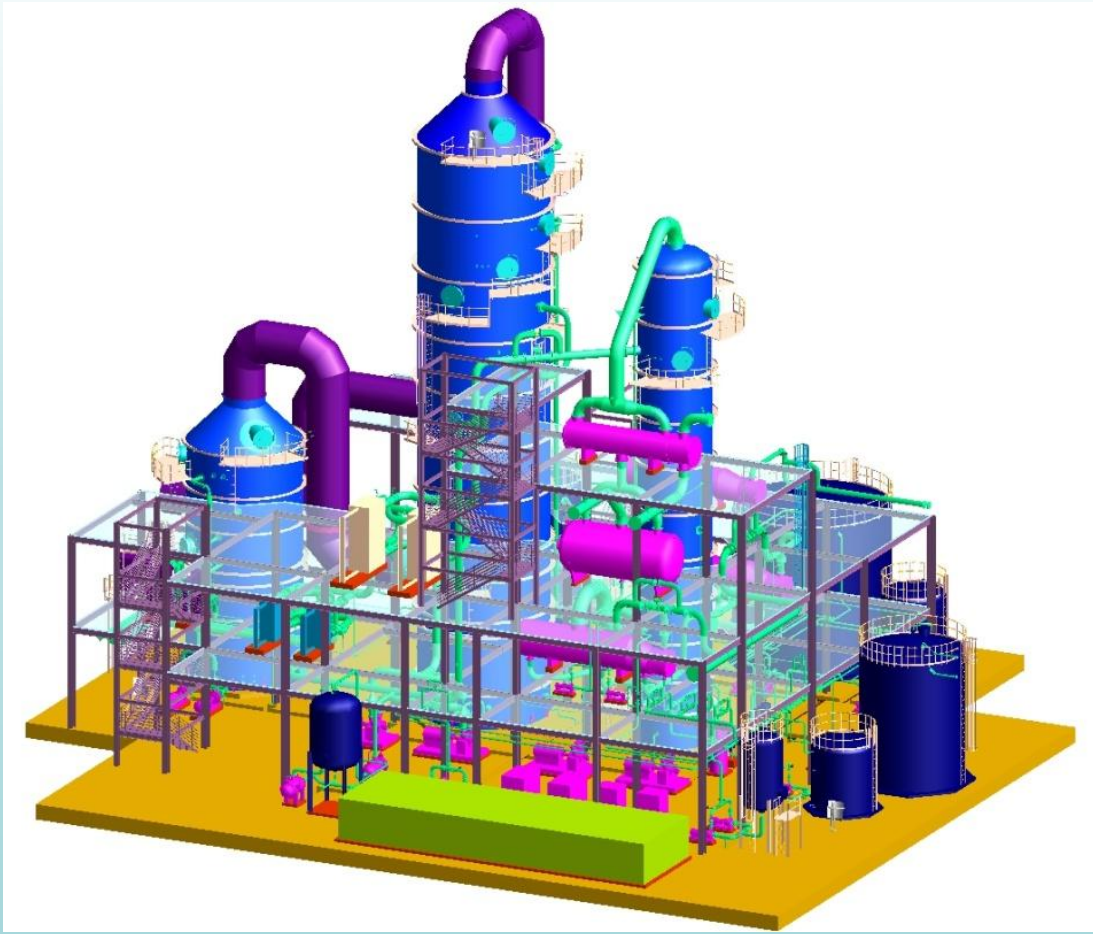


FutureGen 2.0 Air Emissions

Project Air Emissions	
Emissions Constituent	**lb/hr (lb/MBtu), HHV Basis**
CO	4.8 (0.0031)
NO_x	35.4 (0.023)
VOM	5.7 (0.0036)
PM (Total)	Negligible
SO_2	0.02 (0.000013)
SO_3	Negligible
HCl	Negligible
HF	Negligible
Hg	Negligible
CO2 Recovery, Production, and Quality	
CO_2 Recovery (mass basis)	**98%**
Mass flow (CO_2)	319 klbs/hr, 3,828 tpd 1.08 million metric tons/year (based on 85% capacity factor)
Pressure	2,100 psig
Temperature	71°F
CO_2 content	**99.8%** (by mass, dry basis)

RSAT™ Post Combustion CO_2 Capture Technology

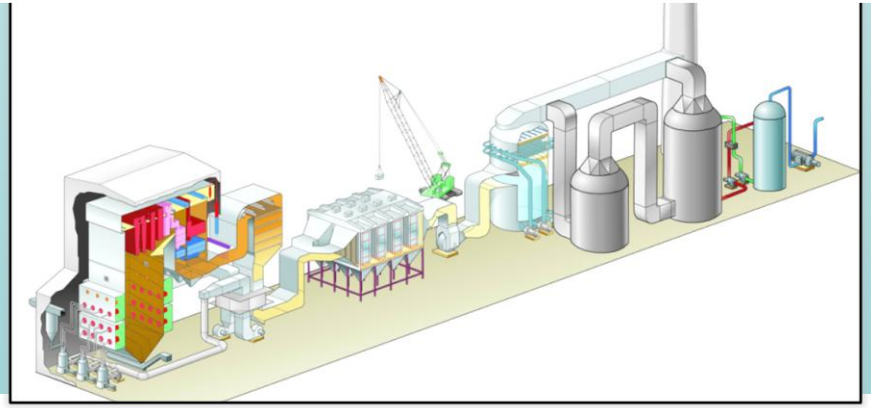
- Regenerable Solvent Absorption Technology (RSAT™)
- Up to 90% CO_2 capture
- Advanced solvent-based scrubber
- Applications: new or retrofit; coal, oil, natural gas
- Ready for field demonstration



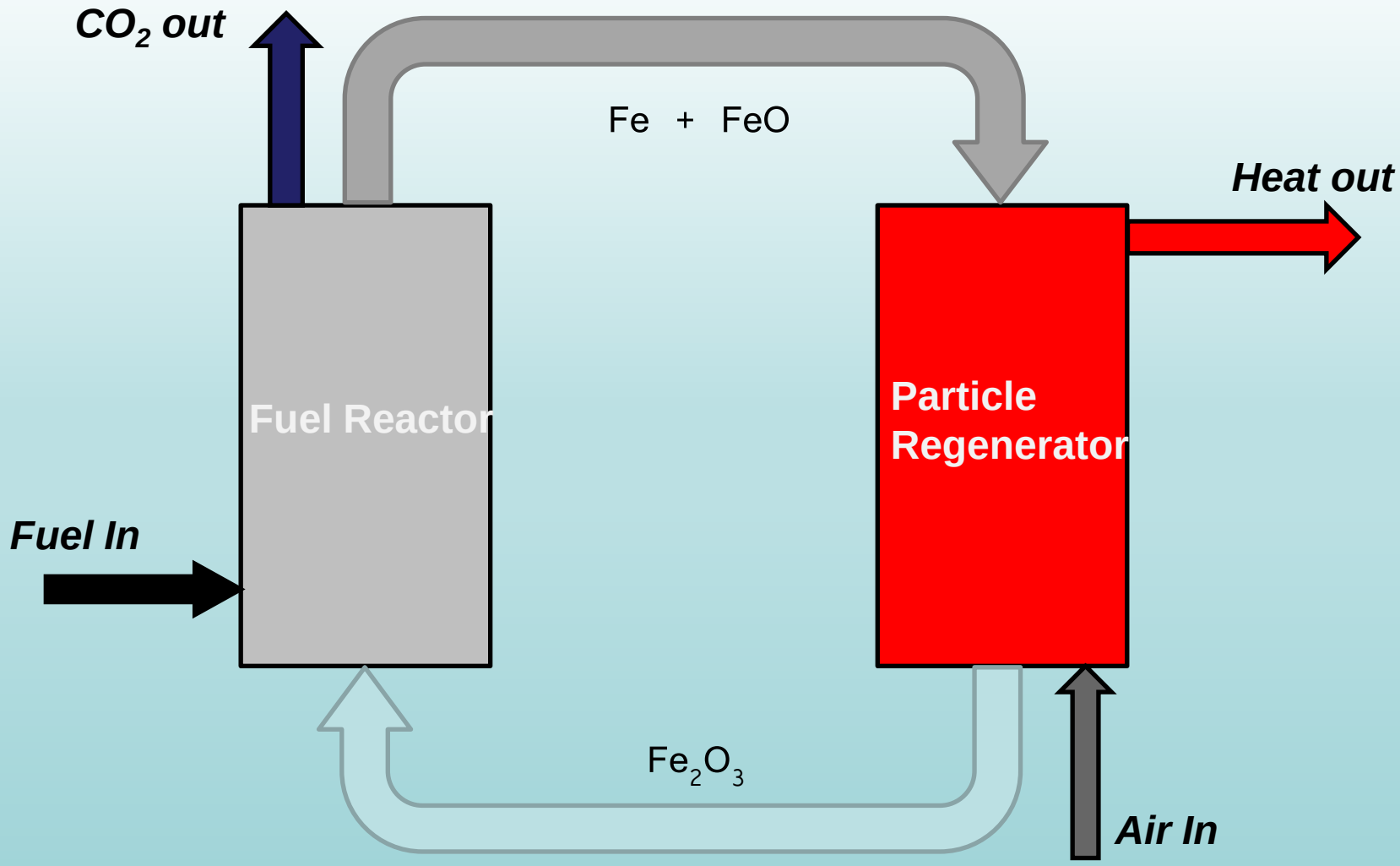
Reference Plant Design 1500 TPD (75 MW)

B&W PGG Post-Combustion CO_2 Capture

Timeline	2005	2010	2015	2020
Econamine FG Plus℠		B&W / Fluor Strategic Alliance		
RSAT™		CO_2 Control Lab; 7 tpd BWRC Pilot Plant; NCCC Testing; Reference Plant	Field Demonstration	Commercial
Advanced Systems			Liquid Solvents, Solid Sorbents, Membranes	



Simplified Chemical Looping Flow Diagram



B&W's Chemical-Looping Program

Advantages of the chemical-looping processes

1. Chemical-looping processes are fuel flexible. They can be modified to produce hydrogen, liquid fuels and generate electricity as part of the process.
2. Eliminates the need for an air separation unit for oxygen production
3. Produces a pure CO2 stream with no additional separation costs.
4. Higher energy efficiencies are possible since chemical-looping processes are not limited by the Carnot cycle.
5. When integrated in coal-to-liquid processes, chemical-looping can increase liquid fuel yields while reducing CO2 emissions.

B&W and OSU are jointly developing two chemical-looping technologies:

1. Syngas-chemical looping for the production of hydrogen or liquid fuels from coal-derived syngas
2. Coal-direct chemical-looping for the production of hydrogen, liquid fuels and power

Conclusions

- While the UMACT and the proposed GHG rules have effectively prohibited new coal and brought certainty to the need for CCS fossil fuel plants, the low price of natural gas will dictate any new capacity additions in the near term.
- Unless gas prices exceed $10 dollars/MBtu it is unlikely that coal with CCS will be able to compete.
- CCS technologies continue to be developed albeit at a slow pace. Public funding is still required as the cost to develop these technologies remains high but dollar amounts are limited with the poor economic conditions.
- Even though demonstration projects for first generation technologies are yet to be completed the reality that these technologies will be very expensive to deploy is settling in.
- Second generation CCS technologies offer promise of lowering cost , they are years away from being proven at reasonable scale and the cost will still be significant.
- Public acceptance for permanent storage of large volumes of CO2 is still a question.