




ELECTRIC POWER RESEARCH INSTITUTE

Introduction of Large Power Plants with CO_2 Capture and Compression

DOE CO_2 Compression Workshop
Gaithersburg, MD

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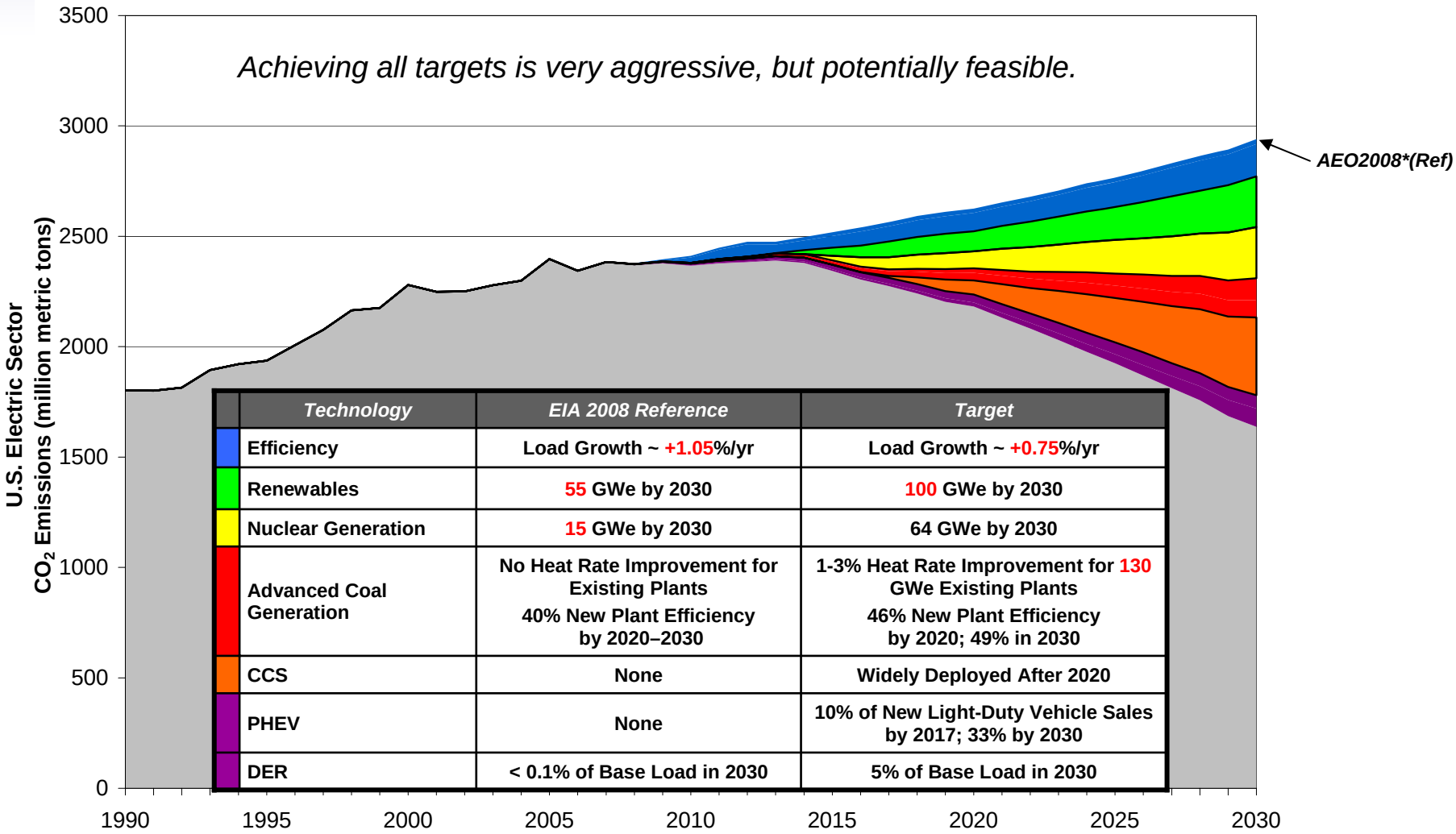
EPRI Prism Analysis (2008 Revision)

Technical Potential for CO_2 Reductions



	Technology	EIA 2008 Reference	Target
	Efficiency	Load Growth ~ +1.05%/yr	Load Growth ~ +0.75%/yr
	Renewables	55 GWe by 2030	100 GWe by 2030
	Nuclear Generation	15 GWe by 2030	64 GWe by 2030
	Advanced Coal Generation	No Heat Rate Improvement for Existing Plants 40% New Plant Efficiency by 2020–2030	1-3% Heat Rate Improvement for 130 GWe Existing Plants 46% New Plant Efficiency by 2020; 49% in 2030
	CCS	None	Widely Deployed After 2020
	PHEV	None	10% of New Light-Duty Vehicle Sales by 2017; 33% by 2030
	DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

***Energy Information Administration (EIA) Annual Energy Outlook (AEO)**

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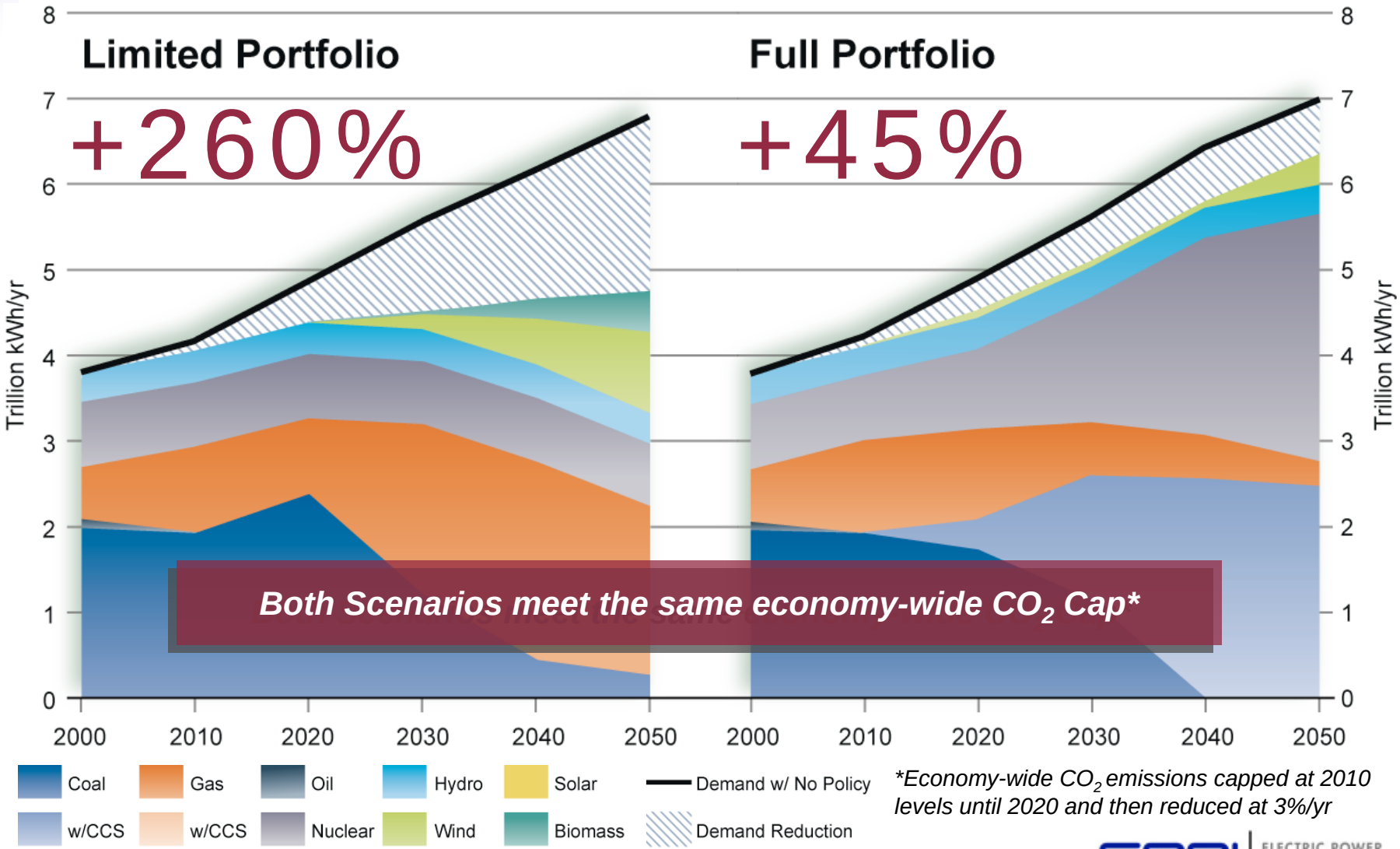
EPRI MERGE Analysis (2008 Revision)

Increase in Real Electricity Prices…2000 to 2050



**Economy-wide CO_2 emissions capped at 2010 levels until 2020 and then reduced at 3%/yr*

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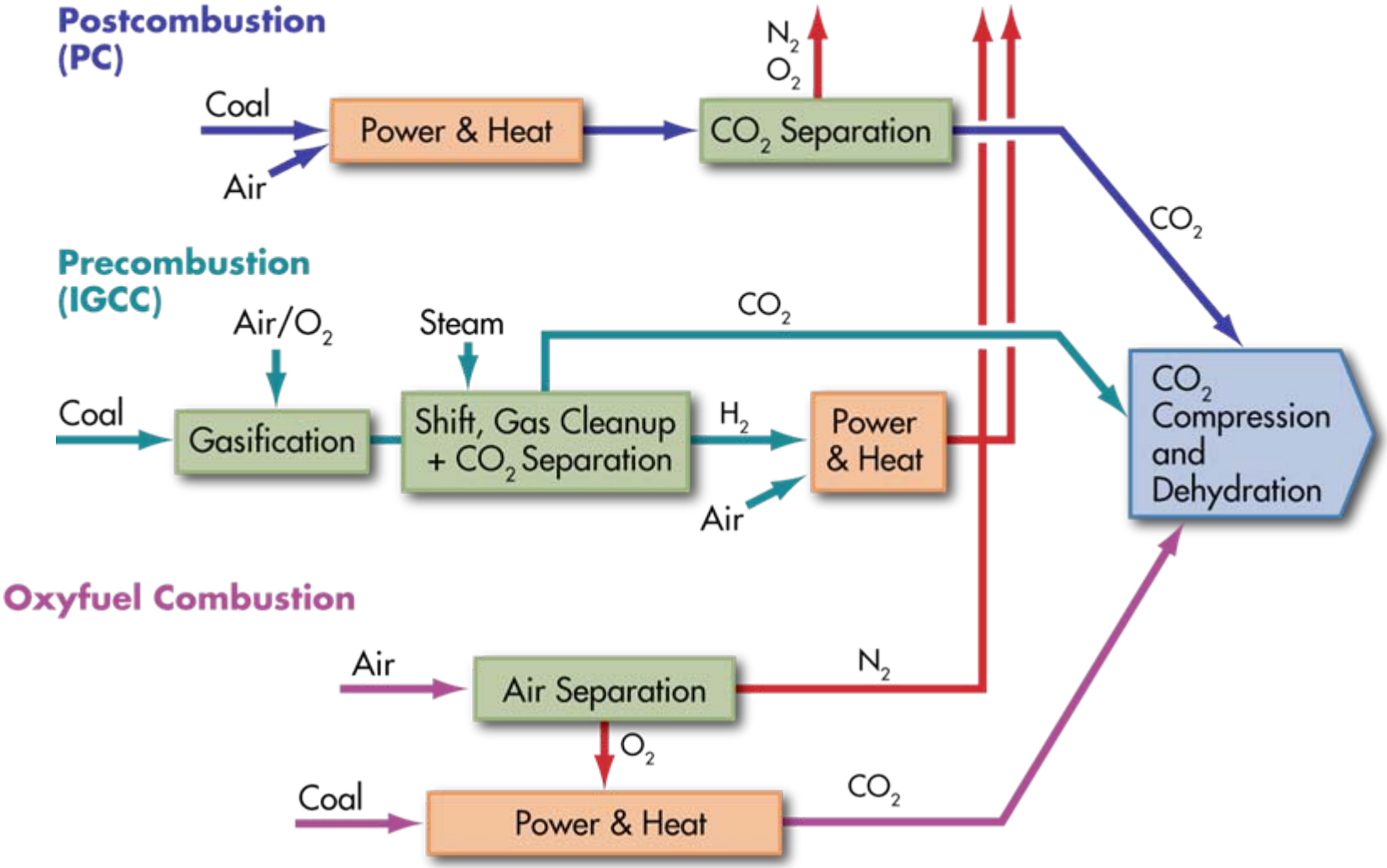
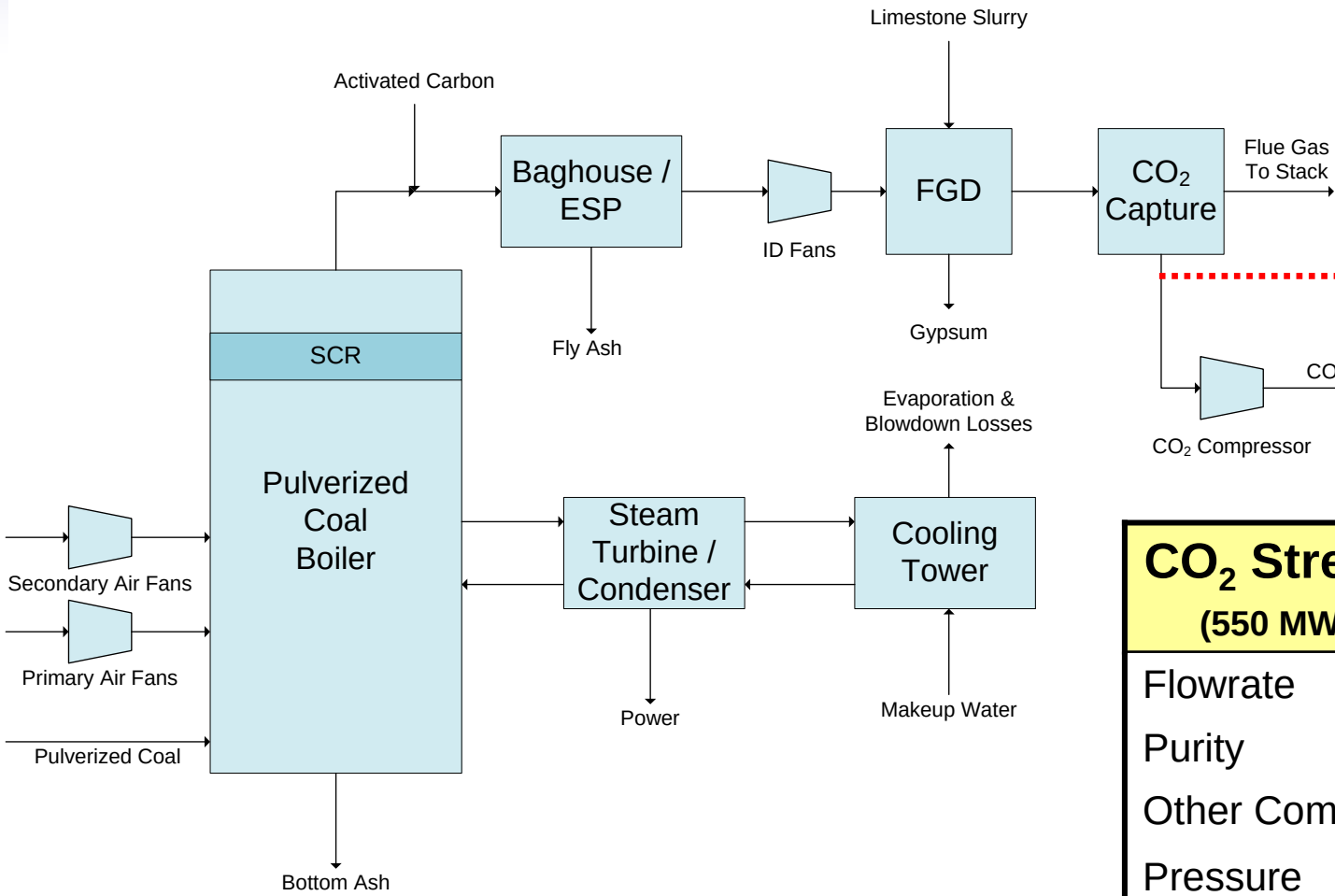
Advanced Coal Plants with CCS

Overview of Power & CO_2 Capture Technologies



Advanced Coal Plants with CCS

Pulverized Coal w/CCS Process Flow Diagram



CO_2 Stream Properties (550 MW net plant output)	
Flowrate	15,000+ tpd
Purity	98%+
Other Comp.	O_2, SO_2, H_2O
Pressure	15 to 25 psia
Temperature	~70°F

Data Source: NETL Pulverized Coal OxyCombustion Plants, August 2007

Advanced Coal Plants with CCS

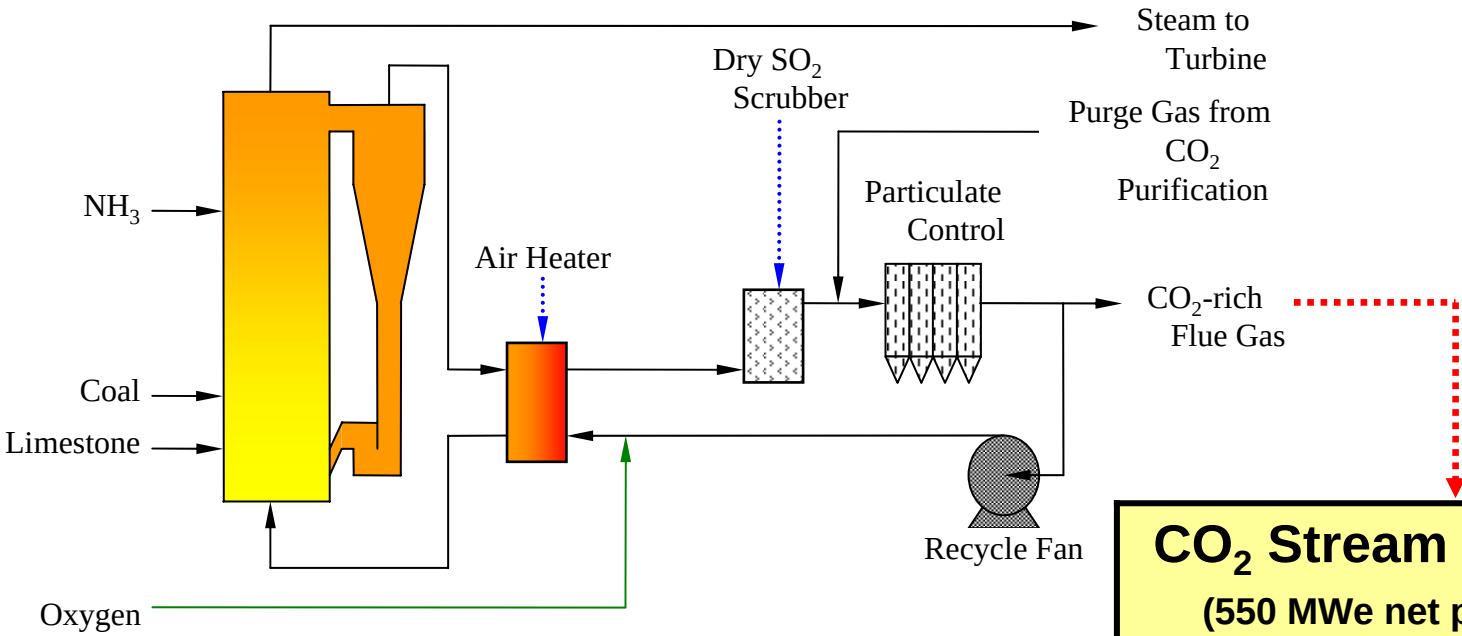
Pulverized Coal w/CCS Current Experience

- **Three U.S. small plants in operation today**
  - Monoethanolamine (MEA)-based
- **CO_2 sold as a product or used**
  - Freezing chickens
  - Soda pop, baking soda
  - ~140 \$/ton CO_2
- **300 metric tons recovered per day**
  - ~15-MWe power plant equivalent
- **Many pilots planned and in development**
  - 1.7-MWe chilled ammonia pilot (at right)
  - Many other processes under development

PC + CO_2 Capture: Technology Exists but Larger-Scale Demonstrations & Less-Expensive Processes Needed

Advanced Coal Plants with CCS

OxyFuel Combustion w/CCS Process Flow Diagram



CO_2 Stream Properties (550 MWe net plant output)	
Flowrate	18,000+ tpd
Purity	83 to 90%+
Other Comp.	Air, SO_2, H_2O
Pressure	<15 psia
Temperature	~80-100°F

Data Source: NETL Pulverized Coal OxyCombustion Plants, August 2007

Advanced Coal Plants with CCS

OxyFuel w/CCS Current Experience

No commercial power plants use oxy-combustion today, but:

- Several pilot-scale (~1 MW) test units operating
- Vattenfall 30-MWth pilot plant under construction
- B&W 30-MWth test facility in Ohio

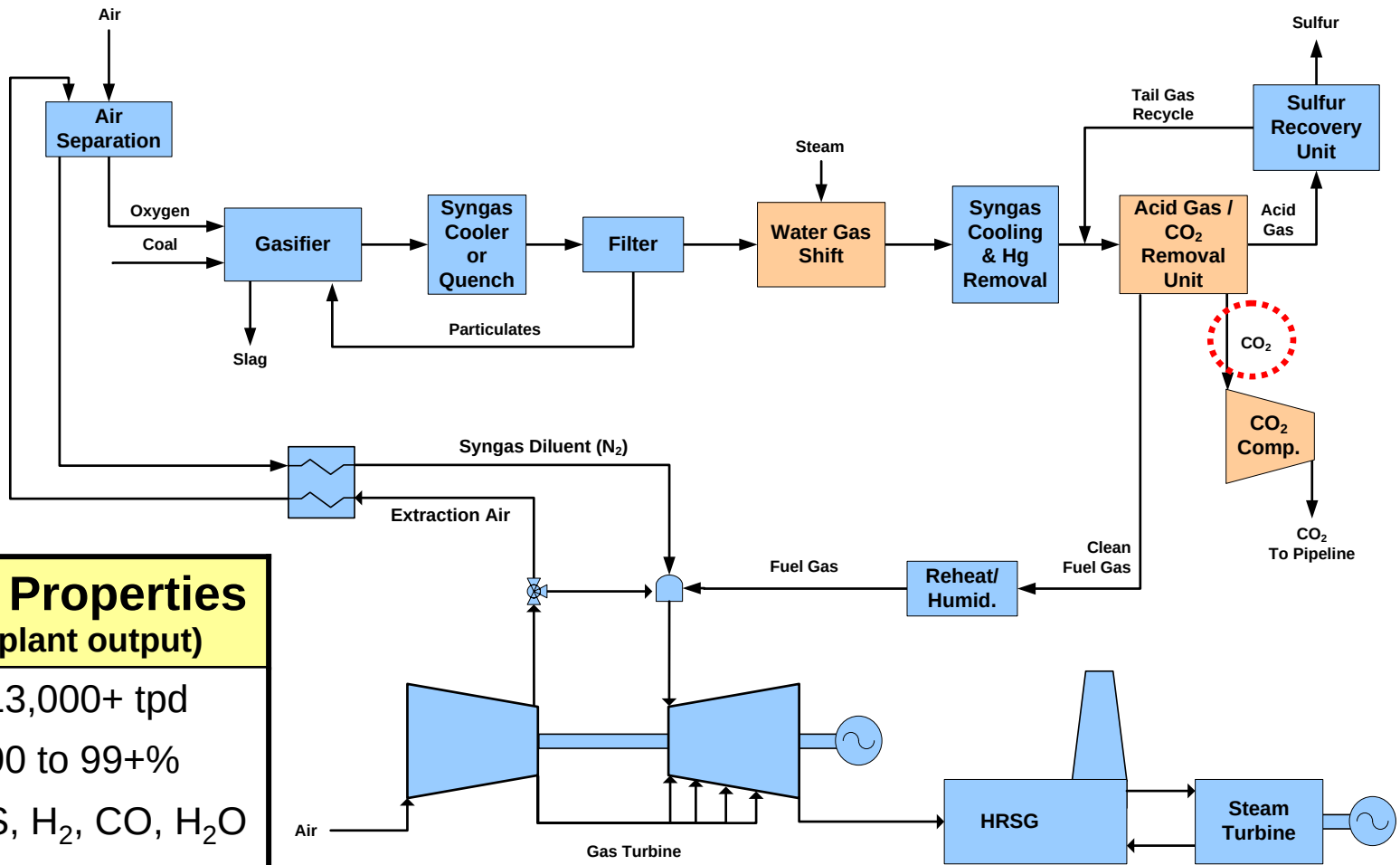
Significant design work under way:

- Boiler design to limit air ingress and reduce flue gas recycle
- FGD for deeper sulfur removal
- Flue gas condensation for water separation from CO_2
- CO_2 purification to limit amount of O_2, N_2, Ar, SO_2 and other constituents in the CO_2 product stream

Technology under consideration for Greenfield and retrofit applications

Advanced Coal Plants with CCS

IGCC w/CCS Process Flow Diagram



CO_2 Stream Properties (550 MWe net plant output)	
Flowrate	13,000+ tpd
Purity	90 to 99+%
Other Comp.	S, H_2, CO, H_2O
Pressure	15 to 300 psia
Temperature	~100°F

Advanced Coal Plants with CCS

Gasification w/CCS operating experience

- **IGCC and CO_2 removal offered commercially**
  - Have not operated in an integrated manner
- **Three U.S. non-power facilities and many plants in China recover CO_2**
  - Coffeyville
  - Eastman
  - Great Plains
- **Great Plains recovered CO_2 used for EOR**
  - 2.7 million tons CO_2 per year
  - ~340 MWe if it were an IGCC
- **Several demonstrations and commercial projects in early development at present**

IGCC + CO_2 capture – Ready for demonstration but need to lower costs

Advanced Coal Plants with CCS

CO_2 Product Stream Compositions

	PC[1]	OxyFuel[2]	IGCC[3]
CO_2	0.98	0.83	0.95 – 0.99+
Moisture	0.01	0.00	<1000 ppm
Total Sulfur (H_2S, COS, SO_2)	<0.01	0.01	50-1000 ppm
Combustibles (H_2, CH_4, CO, etc.)	0.00	0.00	0.05 – 0.02
Inerts (N_2, Ar, etc.)	Trace	0.16	Trace
Total	**1.0**	**1.0**	**1.0**
Flowrate (tpd)	**10,000 - 20,000**		
Pressure (psia)	**15 – 30**	**Ambient**	**10 – 300**

1 – CO_2 capture system includes water wash and sulfur polishing

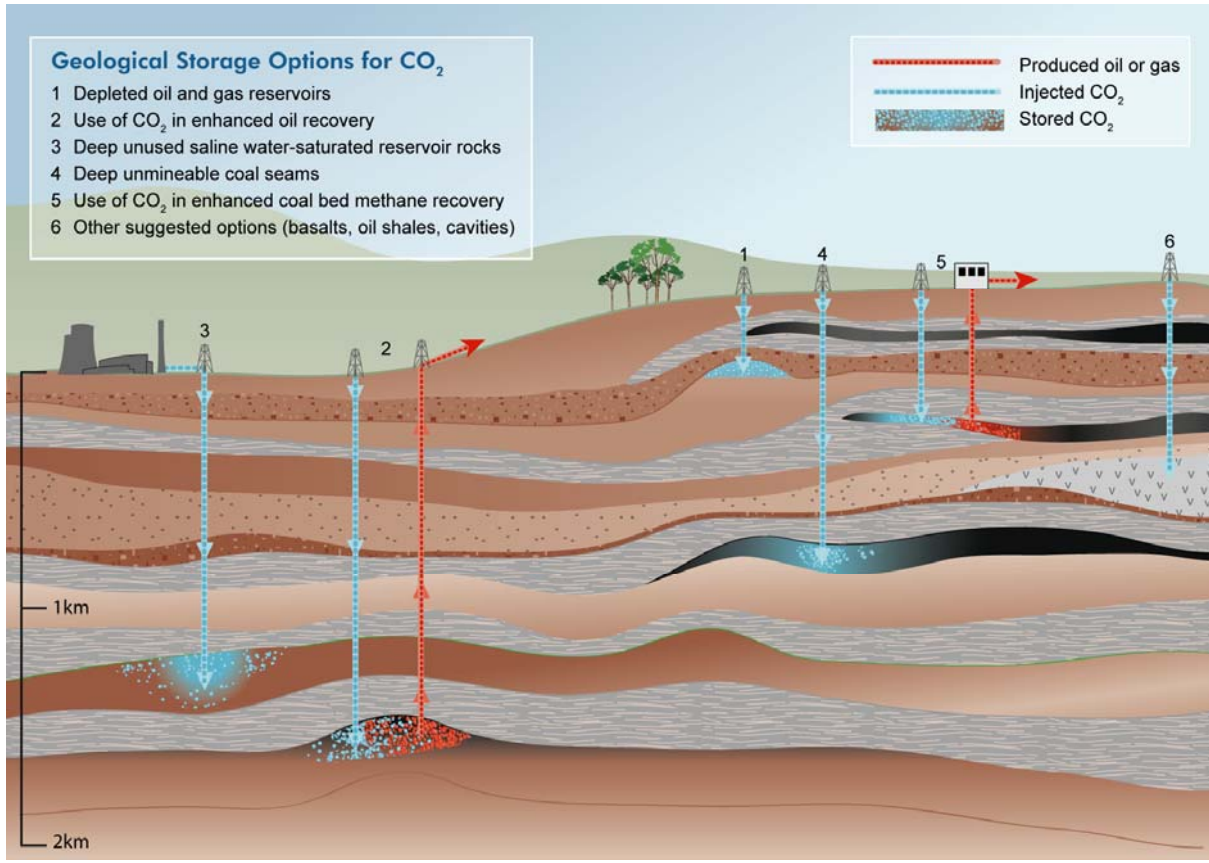
2 – Oxyfuel system includes flue gas condenser to remove water from CO_2

3 – IGCC capture systems are flexible to meet required CO_2 specs

CO_2 capture design may have a significant impact on design of compressors

Advanced Coal Plants with CCS
CO_2 system chain of custody

- **CO_2 capture**
  - Plant design impacts
- **CO_2 compression**
  - In/out pressure, phase selection, reliability
- **Pipeline transport**
  - Metallurgy, venting?
- **CO_2 re-compression**
  - Number, design, other?
- **CO_2 injection**
  - Pressure, chemistry
- **CO_2 end-use**
  - Storage
  - EOR
  - Other



Courtesy of Peter Cook, CO2CRC

What's Next – What's Needed for Coal?

- Acceleration of industry efforts worldwide in addition to governmental efforts
- Enhanced collaboration among industry, R&D and government
- Cost reductions and efficiency improvements for capture "systems"
- Large-scale testing of storage of CO_2 in deep saline reservoirs

Discussion