



2012 NETL CO₂ Capture
Technology Meeting

July 9 – July 12, 2012
Pittsburgh, PA



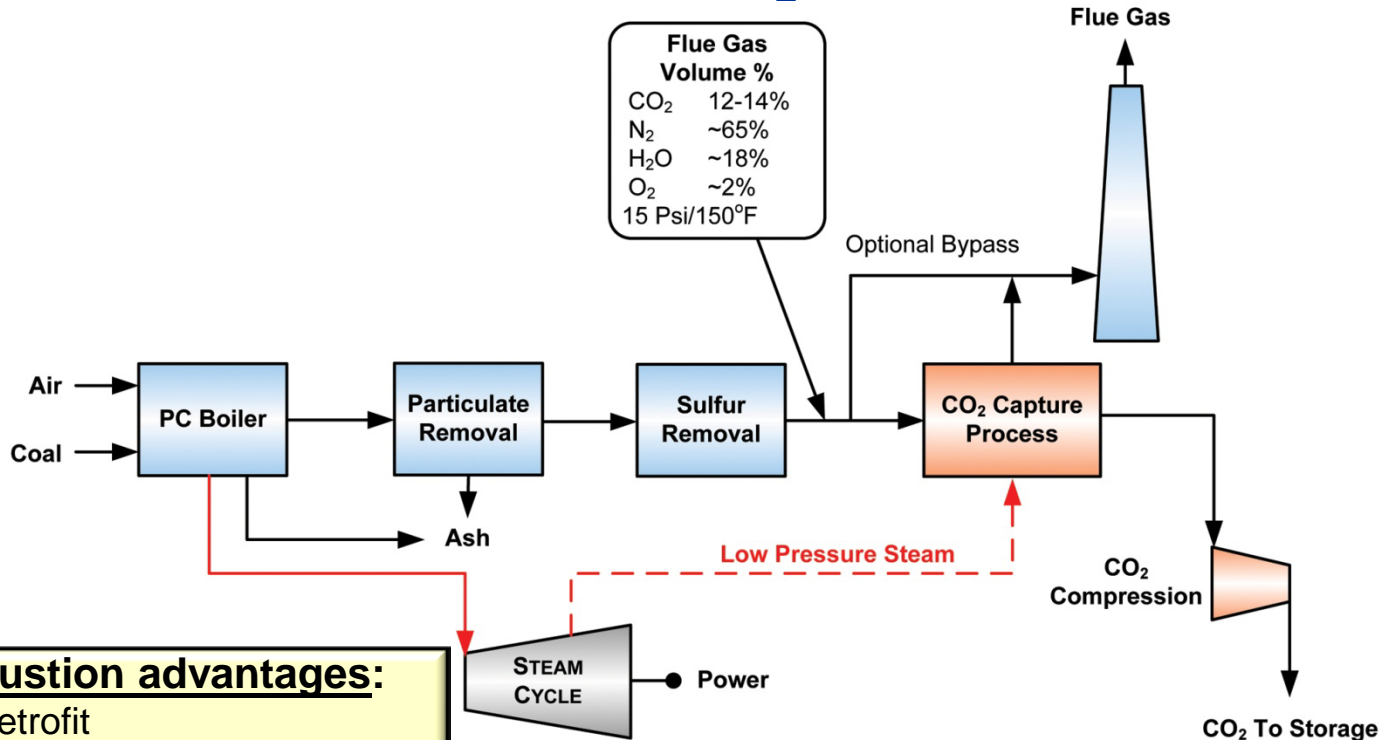
**The U.S. Department of Energy/National
Energy Technology Laboratory's
Carbon Dioxide Capture R&D Program**

Shailesh D. Vora, Technology Manager
Carbon Capture Program



Pulverized Coal Power Plant System

Post-combustion CO₂ Scrubbing



Post-combustion advantages:

- Back-end retrofit
- Slipstream (0 to 90% capture)

Amine scrubbing Advantages:

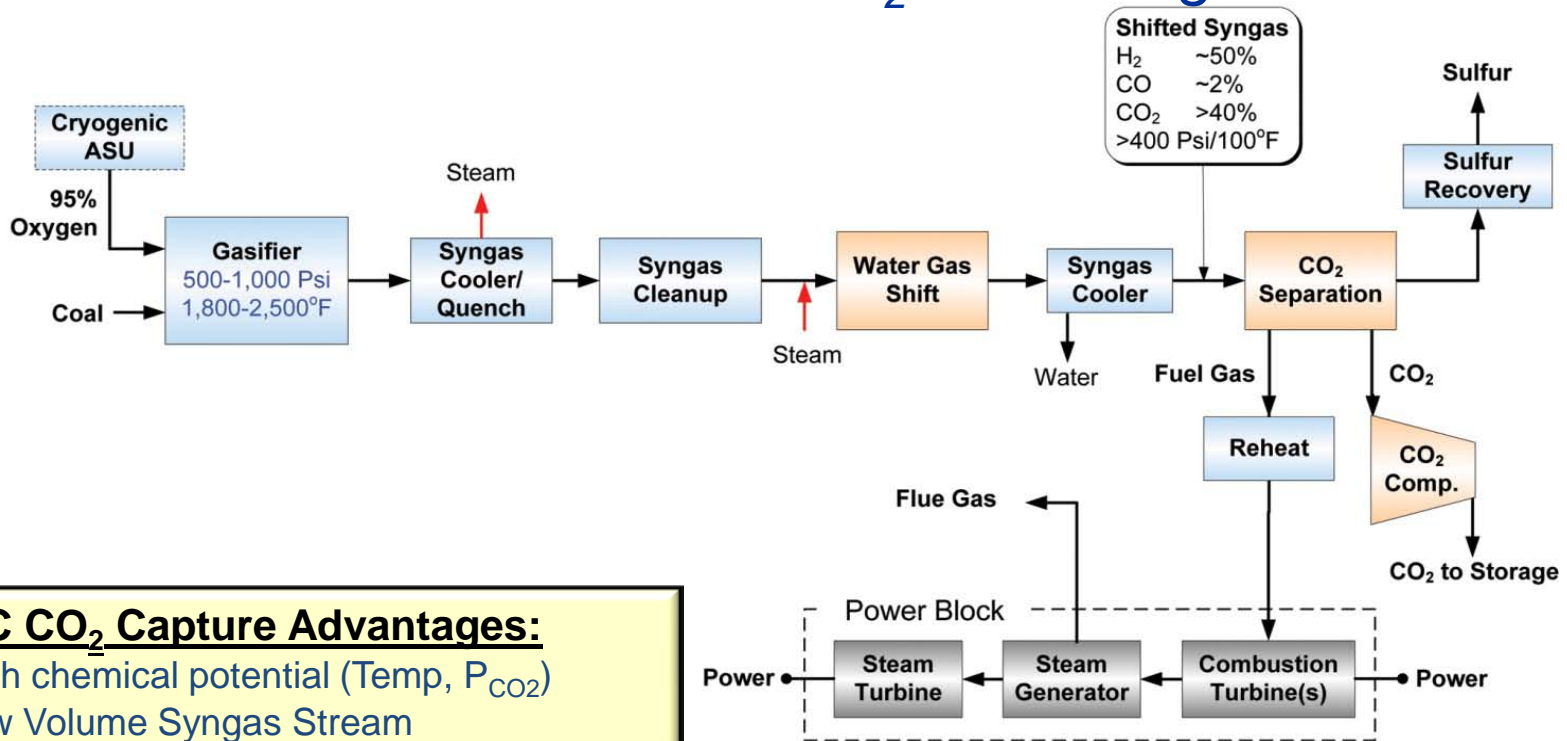
- Proven Technology (Petroleum refining, NG purification)
- Chemical solvent → High loadings at low CO₂ partial pressure
- Relatively cheap chemical (\$2-3/lb)

Key Challenges:

- Dilute flue gas (12-15 volume %)
- 2-3 MM acfm for a 500-600 MWe plant
- ~50% currently scrubbed for SO_x/NO_x
- Increased cooling requirements

IGCC Power Plant System

Pre-combustion CO₂ Scrubbing



IGCC CO₂ Capture Advantages:

- High chemical potential (Temp, P_{CO₂})
- Low Volume Syngas Stream

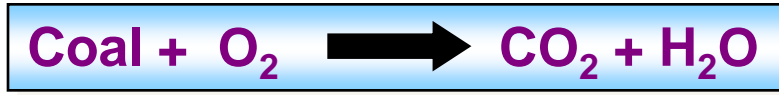
Selexol™ CO₂ Capture Advantages:

- 30+ years of commercial operation (55 worldwide plants)
- Physical Liquid Sorbent
- Highly selective for H₂S and CO₂
- CO₂ is produced at “some” pressure

Key Challenges:

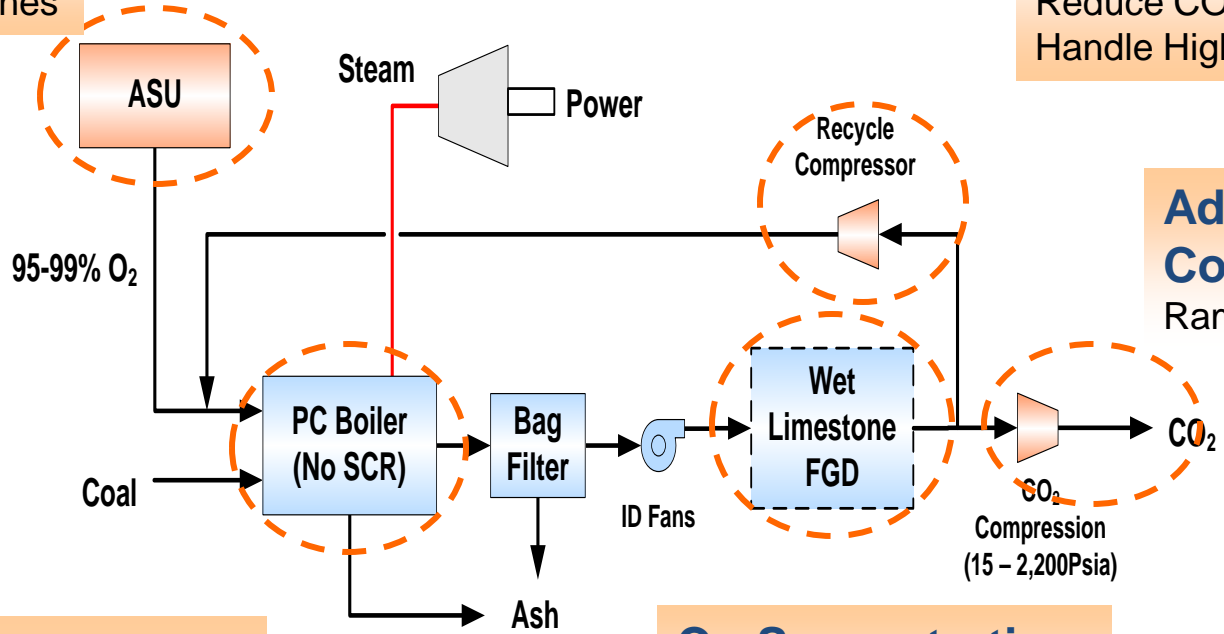
- Complex, integrated power process
- Additional process (WGS) to get high capture rates
- Current technology (Selexol) requires cooling and reheating

Pulverized Coal Oxyfuel Combustion Technology Opportunities



Cheap Oxygen
Oxygen Membranes

Advanced MOC*
Reduce CO₂ Recycle
Handle High Sulfur Con.



Advanced Compression
Ramgen, SwRI

Oxyfuel Boilers
Compact Boiler Designs
Adv. Materials (USC)
Advanced Burners

Co-Sequestration
Multi-pollutant capture

*Materials of Construction

Deployment Barriers for CO₂ Capture On New and Existing Coal Plants Today

1. Scale-up

- Current Post Combustion capture ~200 TPD
- 550 MWe power plant produces 13,000 TPD

2. Energy Penalty

- 20% to 30% less power output

3. Cost

- Increase Cost of Electricity by 80%
- Adds Capital Cost by \$1,500 - \$2,000/kW

4. Regulatory framework

- Transport — pipeline network
- Storage

5. Economies of Scale

- Land, power, water use, transportation, process components, ...



Scale-Up Is An Issue

Laboratory Scale



- **0.1 ft³ Reactor Volume**
- **0.27 scf per minute**

Technically Possible?

Scale-up

Economically Feasible?

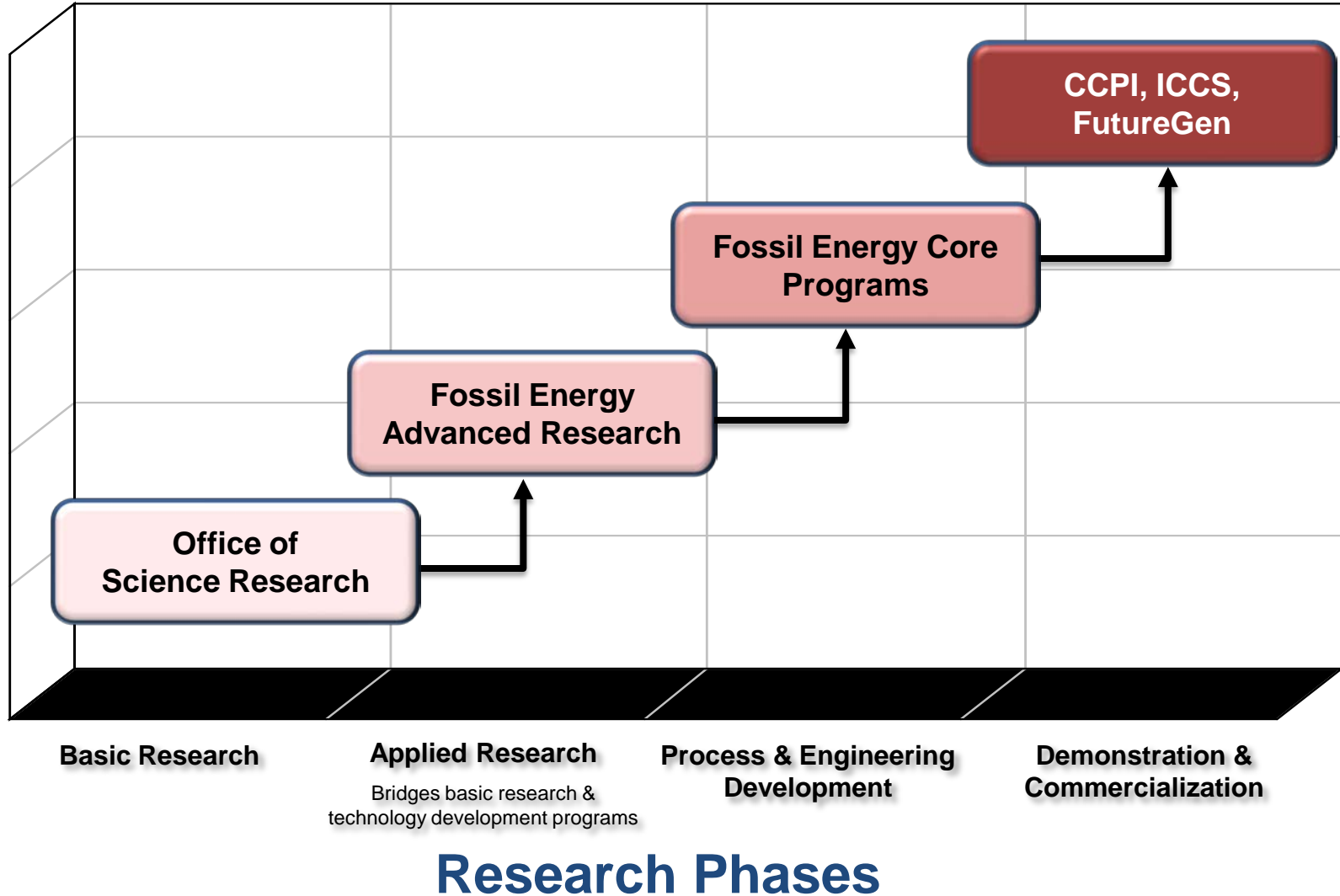
550 MWe Scale



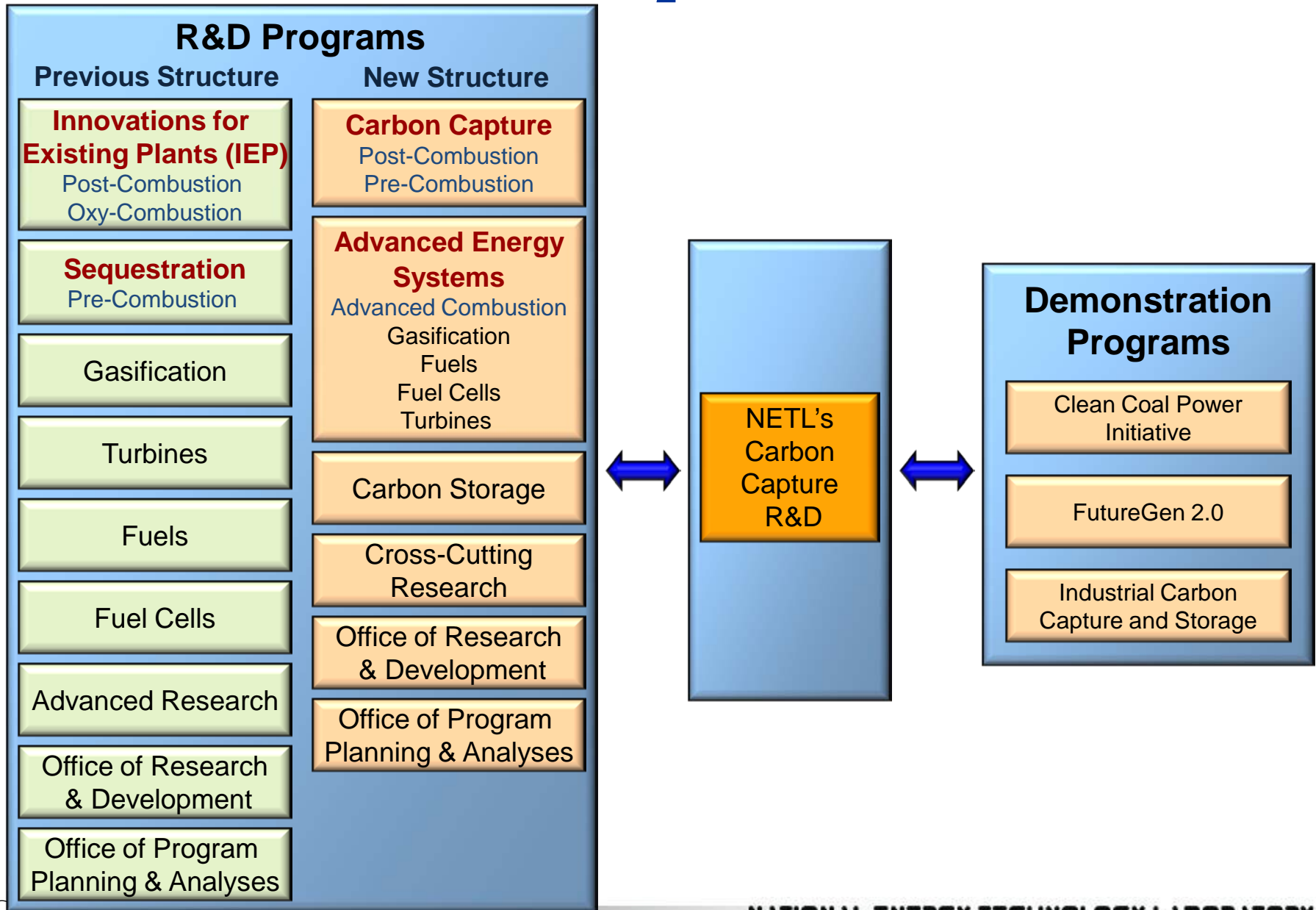
- **57,000 ft³ Reactor Volume**
- **2,000,000 scf per minute**

Stages of Energy RD&D

DOE Research Programs



DOE/NETL CO₂ Capture RD&D



Budget

Previous Structure		New Structure	
	2011 (\$M)		2012 (\$M)
IEP Post-combustion Oxy-combustion	64.9	Carbon Capture	
		Post-combustion	55.5
		Pre-combustion	13.4
Pre-combustion	16.4	Advanced Combustion	10.7
TOTAL	81.3		79.6

Carbon Dioxide Capture R&D Projects

Pre-Combustion

Laboratory/Bench Scale

- < 0.5 MWe
- Simulated or real syngas

1 Solvent

2 Solid Sorbents

7 Membranes

Pilot-Scale

- < 0.1 MWe
- Coal derived syngas *

MTR CO₂ Membrane

MTR H₂ Membrane

WPI H₂ Membrane

Parr Reactor Solvent

Post-Combustion

Laboratory/Bench Scale

- < 0.5 MWe
- Simulated or real flue gas

15 Solvents

9 Solid Sorbents

7 Membranes

Pilot Scale

- 0.5 – 5 MWe
- Coal flue gas

ADA Sorbent 1 MWe

MTR Membrane 1 MWe

Univ. KY Solvent 0.7 MWe

Southern Co. Solvent 1 MWe

Neumann Solvent 0.5 MWe

Linde Solvent 1 MWe

Oxy-combustion

Laboratory/Bench Scale

- < 0.5 MWe

1 Purification

2 Retrofit/Modeling

1 Chemical Looping

Pilot Scale

- 0.5 – 5 MWe

Alstom Oxy-comb. 5 MWe

Jupiter Oxygen 5 MWe

Praxair OTM 1 MWe

Compression

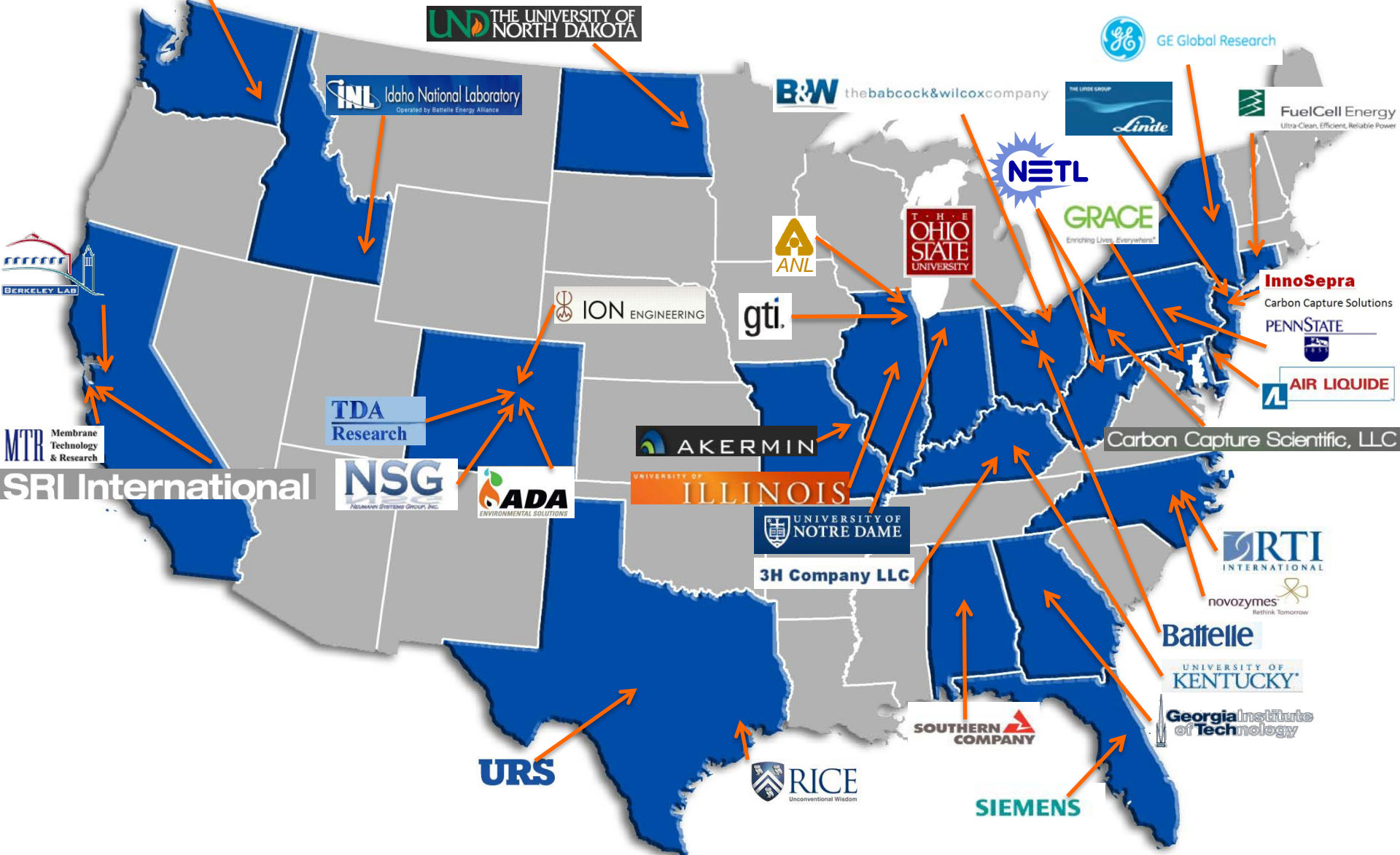
Pilot Scale

- > 0.5 MWe

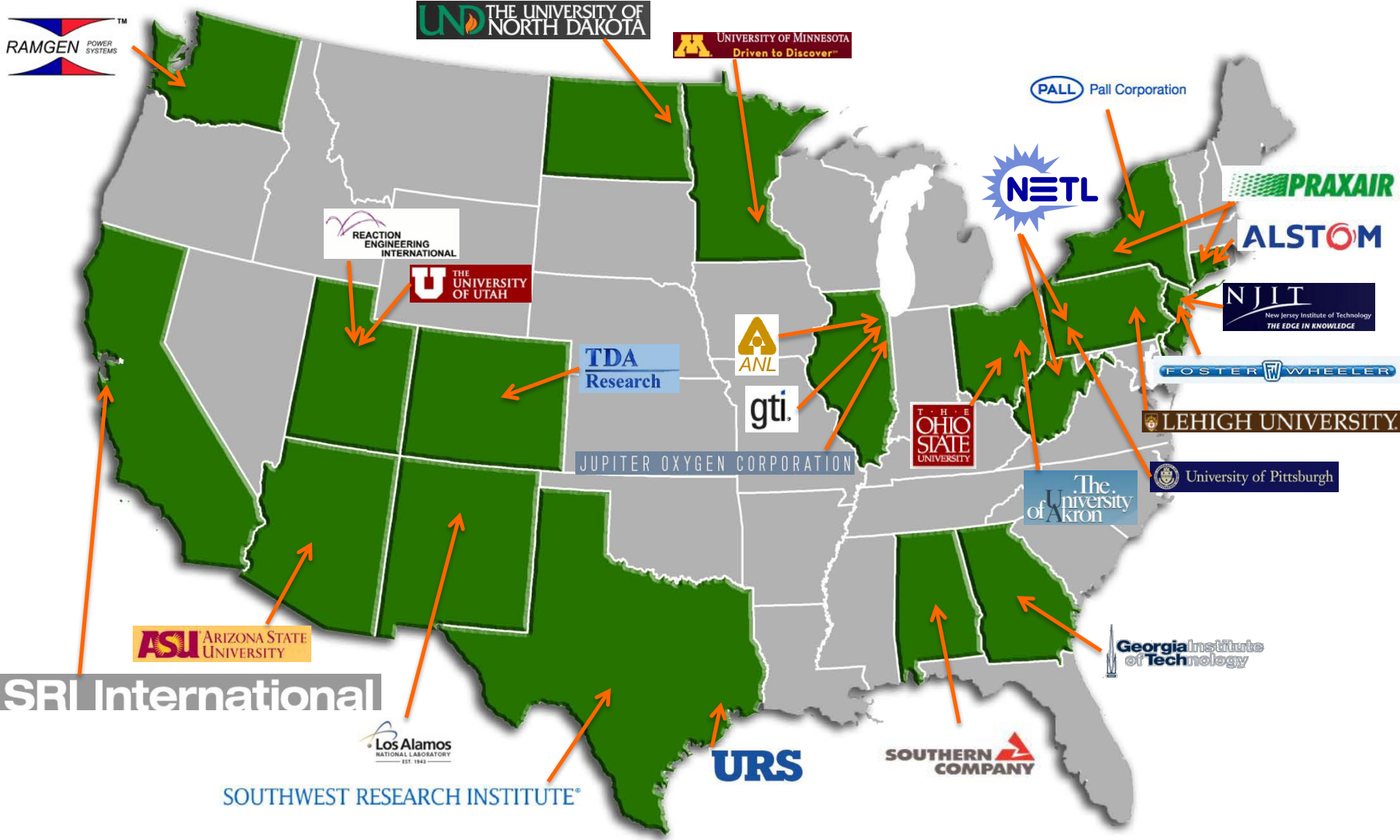
Ramgen 13,000 hp

SwRI 3,000 hp

Post-Combustion



Pre-Combustion, Compression, Oxy-Combustion



National Carbon Capture Center at the Power Systems Development Facility (PSDF)

Wilsonville, AL



Southern Company Services

- 3 MW – 35,000 lb/hr flue gas slip stream from post-combustion – from 880 MW Plant Gaston
- 6 MWe -100 tpd CO₂ – 20,000 lb/hr syngas from TRIG gasifier at PSDF

Offer a unique **flexible R&D facility** where processes can be tested on coal-derived gas at various scales

U.S. Department of Energy National Carbon Capture Center

at the Power Systems Development Facility

PARTICIPANTS:



Managed by Southern Company Services, Inc.

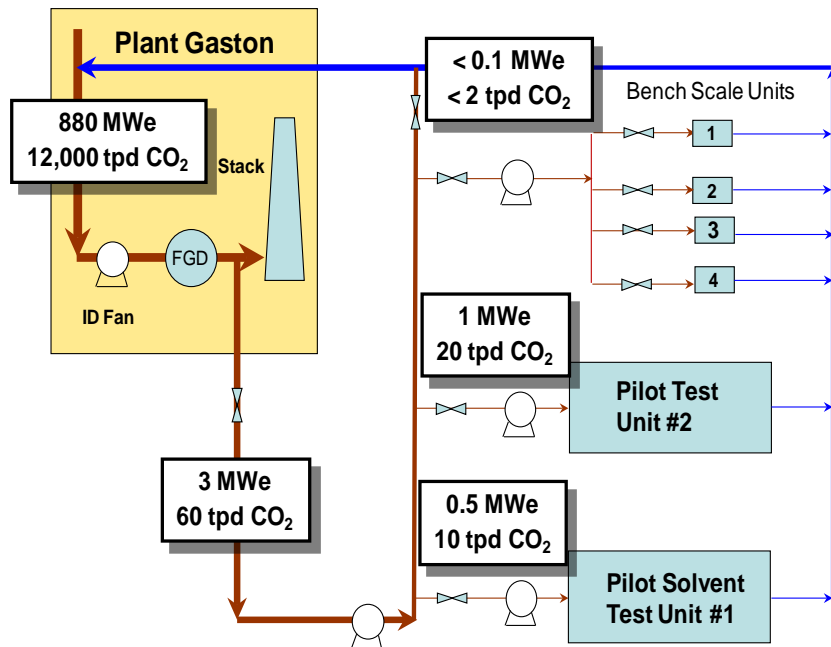
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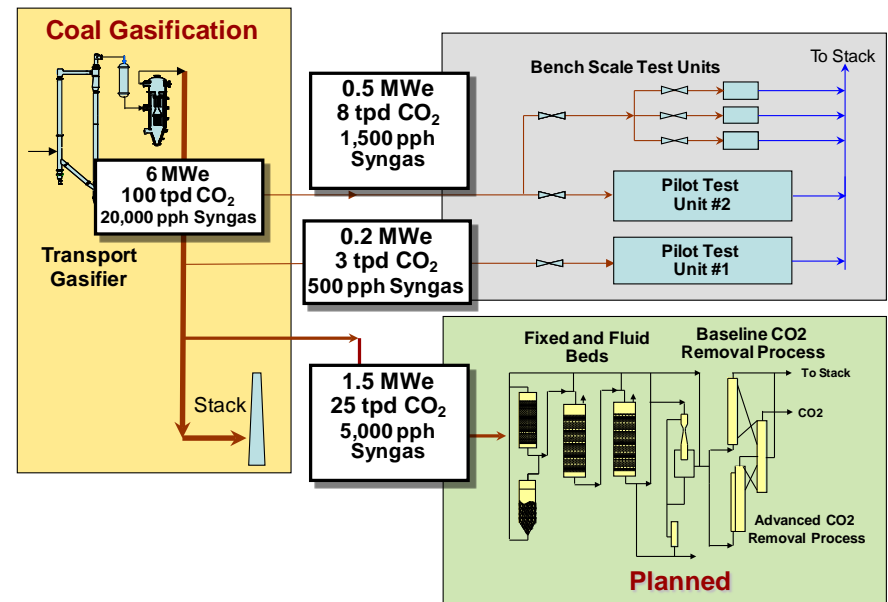
Goal

Develop technologies under realistic conditions that will reduce the cost of advanced coal-fueled power plants with CO₂ capture

Post-combustion



Pre-combustion (IGCC)



CO₂ Capture Program Goals

By 2020, have **ready** for demonstration, 2nd generation technologies that achieve:

Post- and Oxy-combustion

90% CO₂ capture

Compression, transport, storage

< 35% increase in COE

Pre-combustion (IGCC)

90% CO₂ capture

Compression, transport, storage

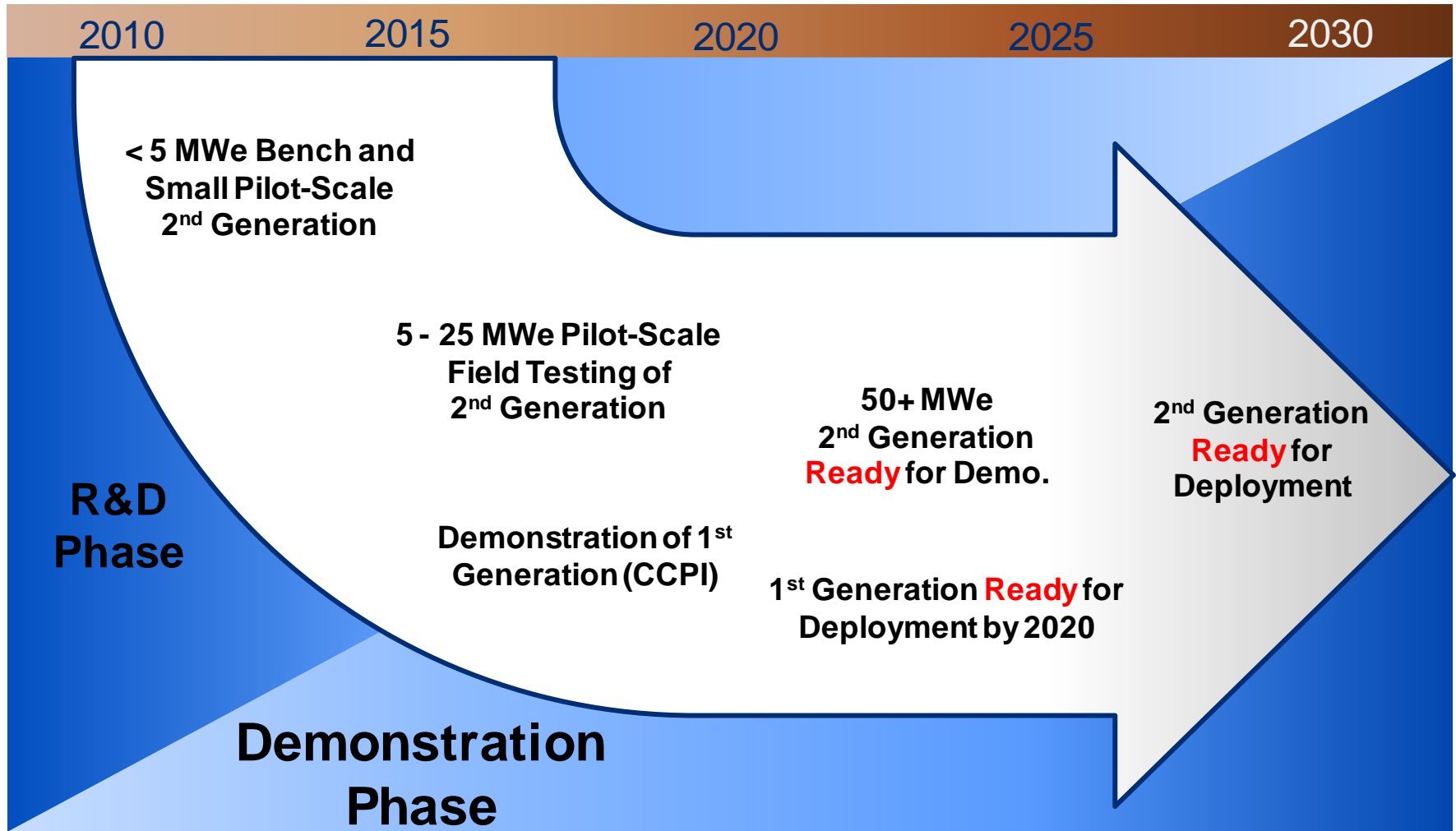
< 10% increase in COE

**Market-Based
Approach**

Putting CO₂ to Work – Carbon Utilization for Enhanced Oil Recovery Carbon Capture Utilization and Storage (CCUS)

- **2nd Generation CCUS technology will result in capture cost of <\$40/tonne**
 - Satisfy strong EOR market opportunities
 - Meet broad acceptance
 - Enable a significant increase in domestic oil production.
- **Transformational CCUS technology will result in capture cost of <\$10/tonne**
 - Open greater domestic EOR opportunities
 - Expand beneficial utilization opportunities such as conversion of CO₂ to higher value chemicals
 - Deliver advanced higher performance coal-fueled energy systems that can compete with NGCC

DOE/NETL CO₂ Capture RD&D Timeline



Accomplishments

- **2012 FOA:** *Advanced Oxy-combustion Technology Development and Scale-up for New and Existing Pulverized Coal Power Plants*
 - **Two-phase Investigation of Pressurized Oxy-combustion and Chemical Looping Combustion Systems**
 - Phase I: Detailed Systems Analysis of Multiple Proposed Technologies
 - Phase II: Downselect Most Promising Systems for Component Development and Testing
 - **Closed April 17, 2012**
 - **Review in Progress**
 - **Announcement of Selections in August**

Accomplishments

- **Technology Readiness Level**
 - Developed in Response to GAO Recommendations
 - Levels Established Based on Scale, Degree of System Integration, and Test Environment in which the Technology has been Successfully Demonstrated
 - Assessment in Progress
- **Updated Carbon Capture Roadmap**
 - Under Development
- **Carbon Capture Program Accomplishments Report**
 - Accomplishments to Date for Pre-, Post-, and Oxy-Combustion Capture, Oxygen Production, and Compression
 - <http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/NETLCO2CaptureRDAccomplishments.pdf>

Looking Forward

FY2013 Pre-Combustion Capture Solicitation

- *“Advanced Pre-combustion Carbon Capture Technology Development and Scale-up for Integrated Gasification Combined Cycle Power Plants”*
- Fall 2012/Winter 2013- FOA scheduled for release
- Summer 2013 - Project selections
- Total funding available - ~\$30 million
- **Areas of Interest: TBD**

Conference Overview

Monday	Post-Combustion Membranes
	Post-Combustion Sorbents
Tuesday	Post-Combustion Sorbents
	Post-Combustion Solvents
Wednesday	Oxy-combustion and Oxygen Production
	Chemical Looping
	CO ₂ Compression
	ARPA-E Capture Projects
	System Studies and Modeling
Thursday	FutureGen 2.0, CCPI & ICCS Demonstrations
	Pre-Combustion Projects

Thanks for Participating!!



For More Information About the NETL Carbon Capture Program

- NETL website:
–www.netl.doe.gov

Reference Shelf

- Annual CO₂ Capture Meeting

- Office of Fossil Energy website:
–www.fe.doe.gov

Dr. Shailesh D. Vora
Technology Manager,
Carbon Capture Program
National Energy Technology Laboratory
U. S. Department of Energy
(Tel) 412-386-7515
shailesh.vora@netl.doe.gov

Innovations for Existing Plants CO₂ Emissions Control



[Capturing Carbon from Existing Coal-Fired Power Plants \(Apr 2009\)](#)
[Annual NETL CO₂ Capture Technology for Existing Plants R&D Meeting Presentations - March 24-26, 2009](#)
[DOENETL's Monthly Carbon Sequestration Newsletter](#)



Welcome to the Innovations for Existing Plants (IEP) Program's CO₂ emissions control R&D homepage. In FY08, the IEP Program redirected its focus to include CO₂ emissions control for existing coal combustion-based plants, e.g. conventional pulverized coal-fired plants. The focus on CO₂ emissions control technology – both post-combustion and oxy-combustion – and related areas of CO₂ compression and CO₂ beneficial reuse is in direct response to the priority placed on advancing technological options for the existing fleet of coal-fired power plants for addressing climate change. In addition to funding R&D projects conducted externally, DOENETL also conducts in-house research to develop new breakthrough concepts for carbon capture that could lead to dramatic improvements in cost and performance relative to today's technologies. The IEP CO₂ emissions control R&D activity also sponsors systems analysis studies of the cost and performance of various carbon capture technologies. The program goal is to develop advanced CO₂ capture and separation technologies for existing power plants that can achieve at least 90% CO₂ removal at no more than a 35% increase in cost of energy services.

- ▶ [Program Goals and Targets](#)
- ▶ [Post-Combustion CO₂ Control](#)
- ▶ [Oxy-Combustion CO₂ Control](#)
- ▶ [CO₂ Compression](#)
- ▶ [CO₂ Beneficial Use](#)
- ▶ [Systems Analysis](#)
- ▶ [CO₂ Emissions Control Reference Shelf](#)

Use the hyperlinks located in the adjacent blue box to find detailed information on the IEP CO₂ emissions control R&D activities. Information on pre-combustion CO₂ emissions control technology applicable to coal gasification-based (e.g. integrated gasification combined cycle) plants is located at the [CO₂ Capture](#) webpage of DOENETL's [Carbon Sequestration Program](#) website.



Prior to FY08, DOENETL's CO₂ emissions control R&D effort was conducted under the [Carbon Sequestration Program](#). With responsibility for existing plant CO₂ emissions control R&D now being conducted under the IEP Program, the Carbon Sequestration Program continues to focus on pre-combustion CO₂ emissions control and geological sequestration. Since its inception in 1997, the Carbon Sequestration Program has been developing both core and supporting technologies through which carbon capture and storage (CCS) will become an effective and economically viable option for reducing CO₂ emissions from coal-based power plants. Successful R&D will enable CCS technology to overcome the existing technical barriers.