NATIONAL ENERGY TECHNOLOGY LABORATORY

2012 NETL CO_2 Capture Technology Meeting

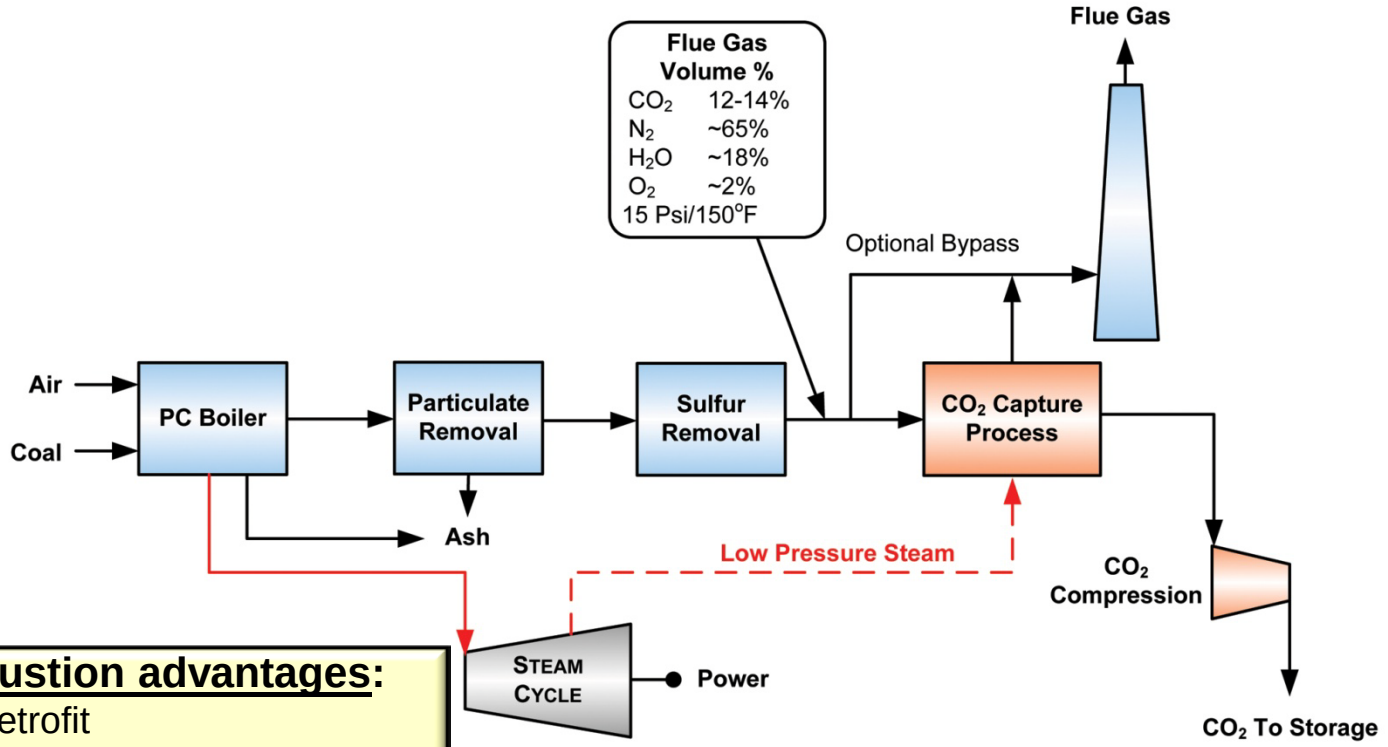
July 9 – July 12, 2012
Pittsburgh, PA

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 CO_2 Scrubbing



Post-combustion advantages:

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

Amine scrubbing Advantages:

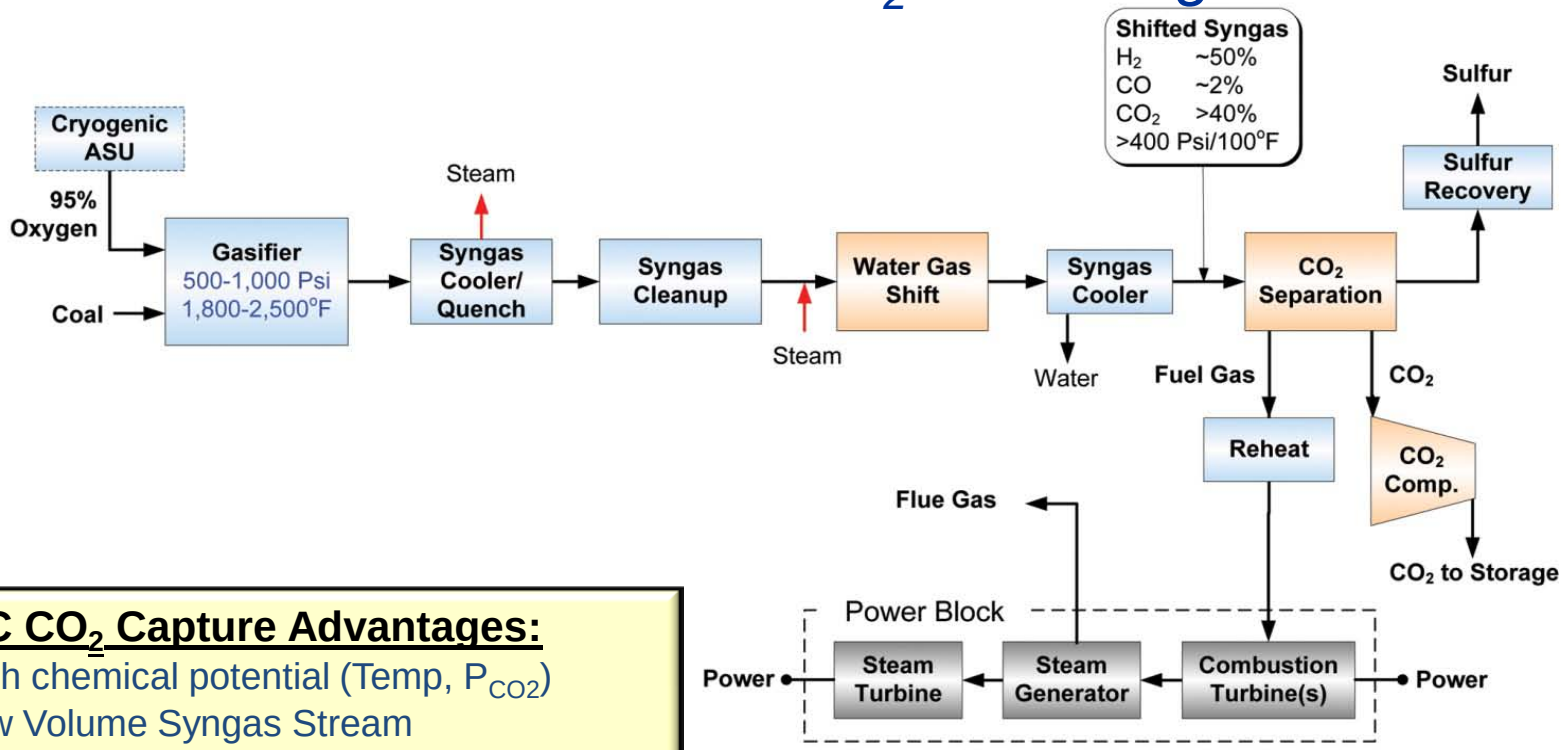
- Proven Technology (Petroleum refining, NG purification)
- Chemical solvent → High loadings at low CO_2 partial pressure
- Relatively cheap chemical ($2-3/lb)

Key Challenges:

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

IGCC Power Plant System

Pre-combustion CO_2 Scrubbing



IGCC CO_2 Capture Advantages:

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

Selexol™ CO_2 Capture Advantages:

- 30+ years of commercial operation (55 worldwide plants)
- Physical Liquid Sorbent
- Highly selective for H_2S and CO_2
- CO_2 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

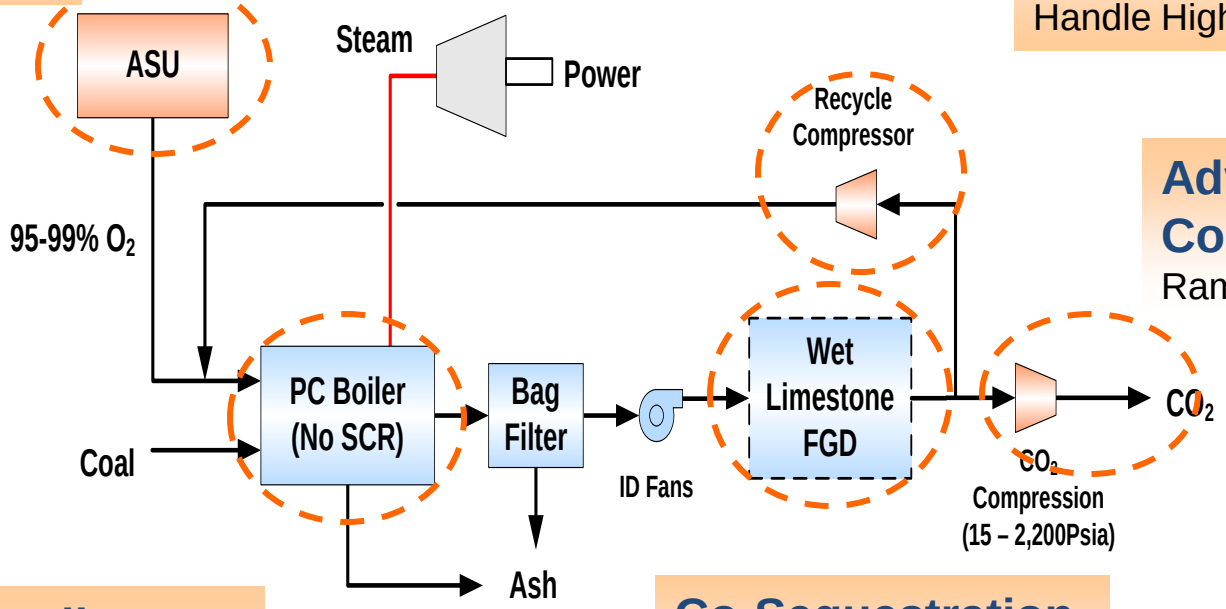
Pulverized Coal Oxyfuel Combustion

Technology Opportunities

$$Coal + O_2 \rightarrow CO_2 + H_2O$$

Cheap Oxygen
Oxygen Membranes

Advanced MOC*
Reduce CO_2 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 CO_2 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 ft^3 Reactor Volume**
- **0.27 scf per minute**

Technically Possible?

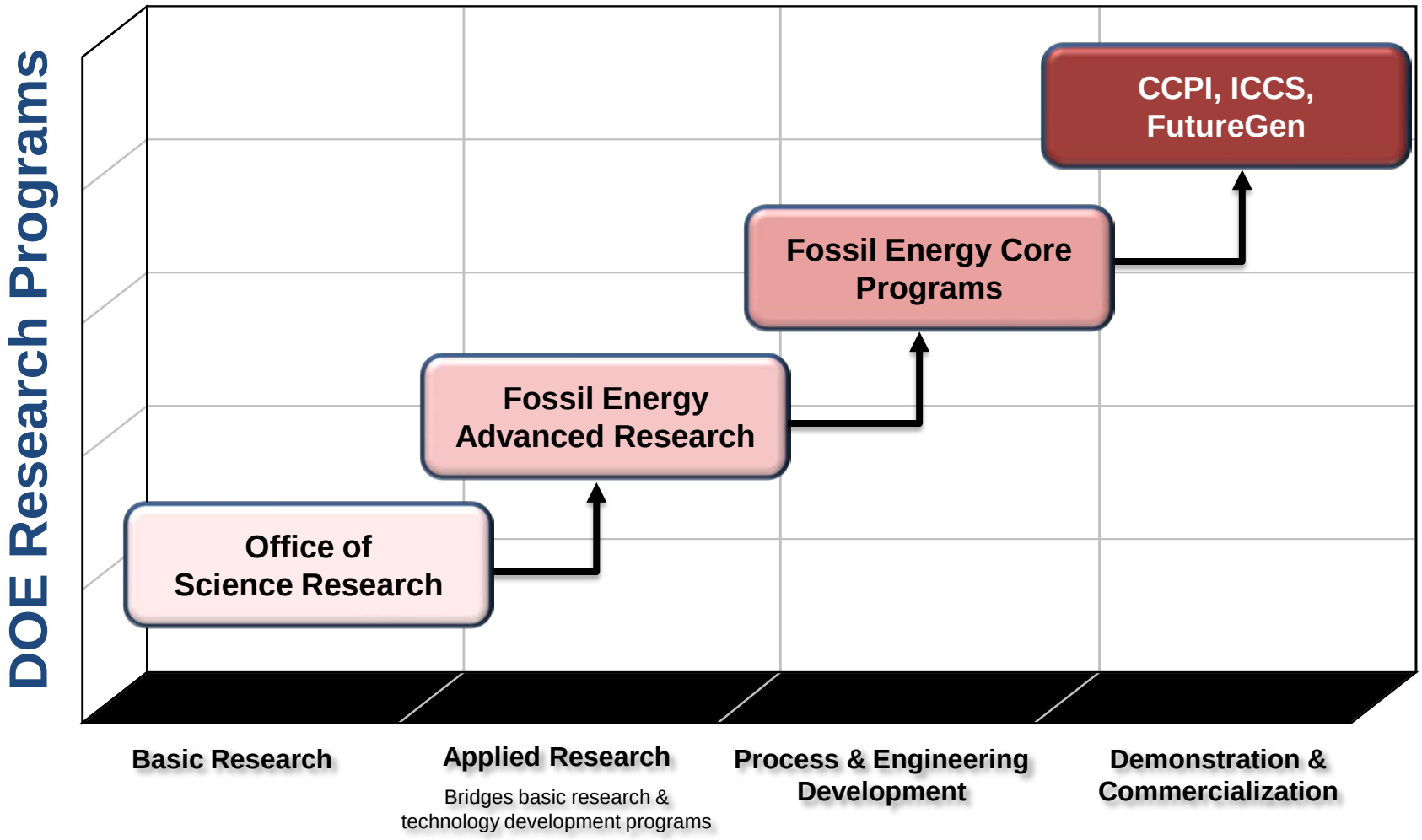
Scale-up

Economically Feasible?

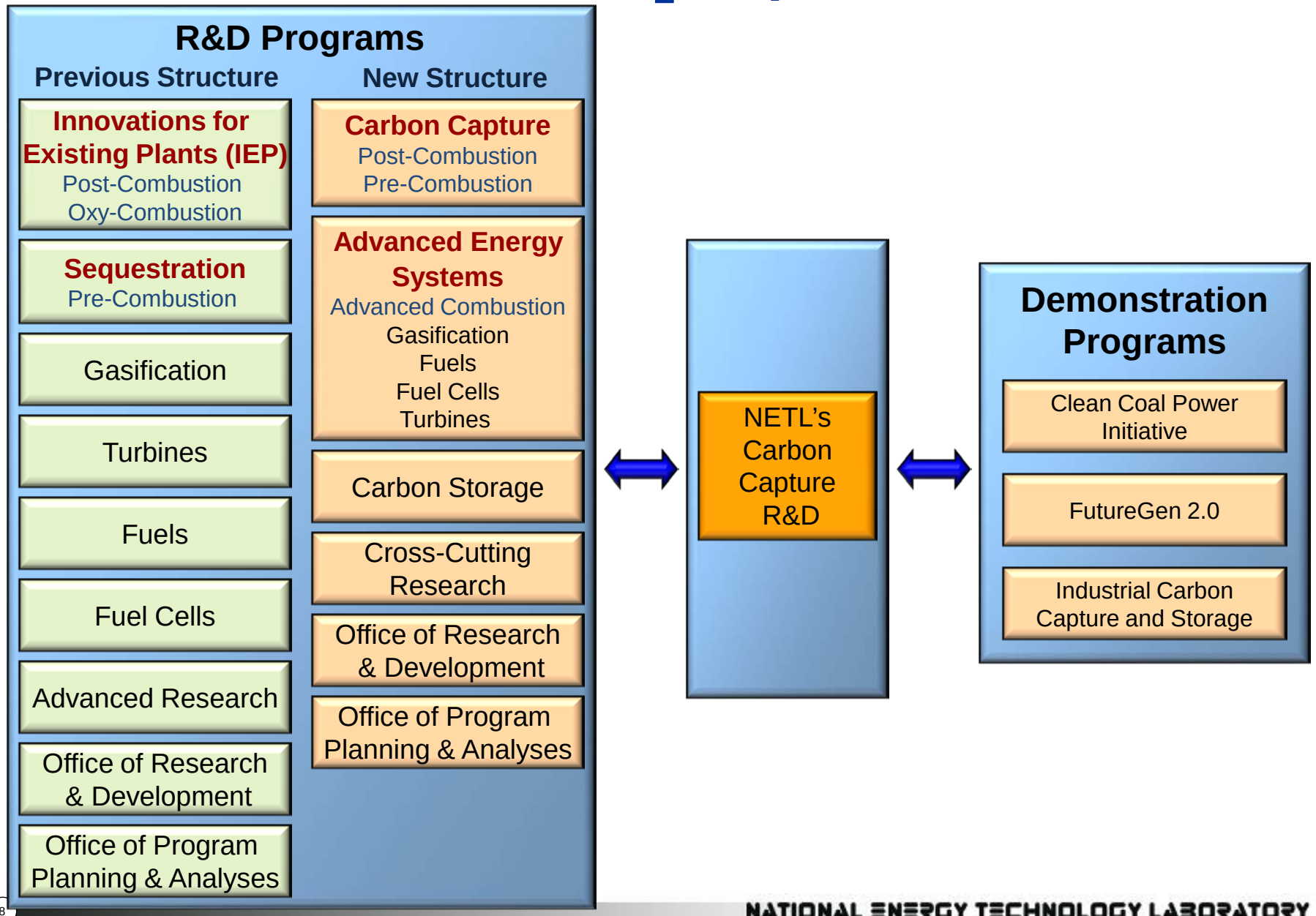
550 MWe Scale

- **57,000 ft^3 Reactor Volume**
- **2,000,000 scf per minute**

Stages of Energy RD&D



DOE/NETL CO_2 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 CO_2 Membrane

MTR H_2 Membrane

WPI H_2 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

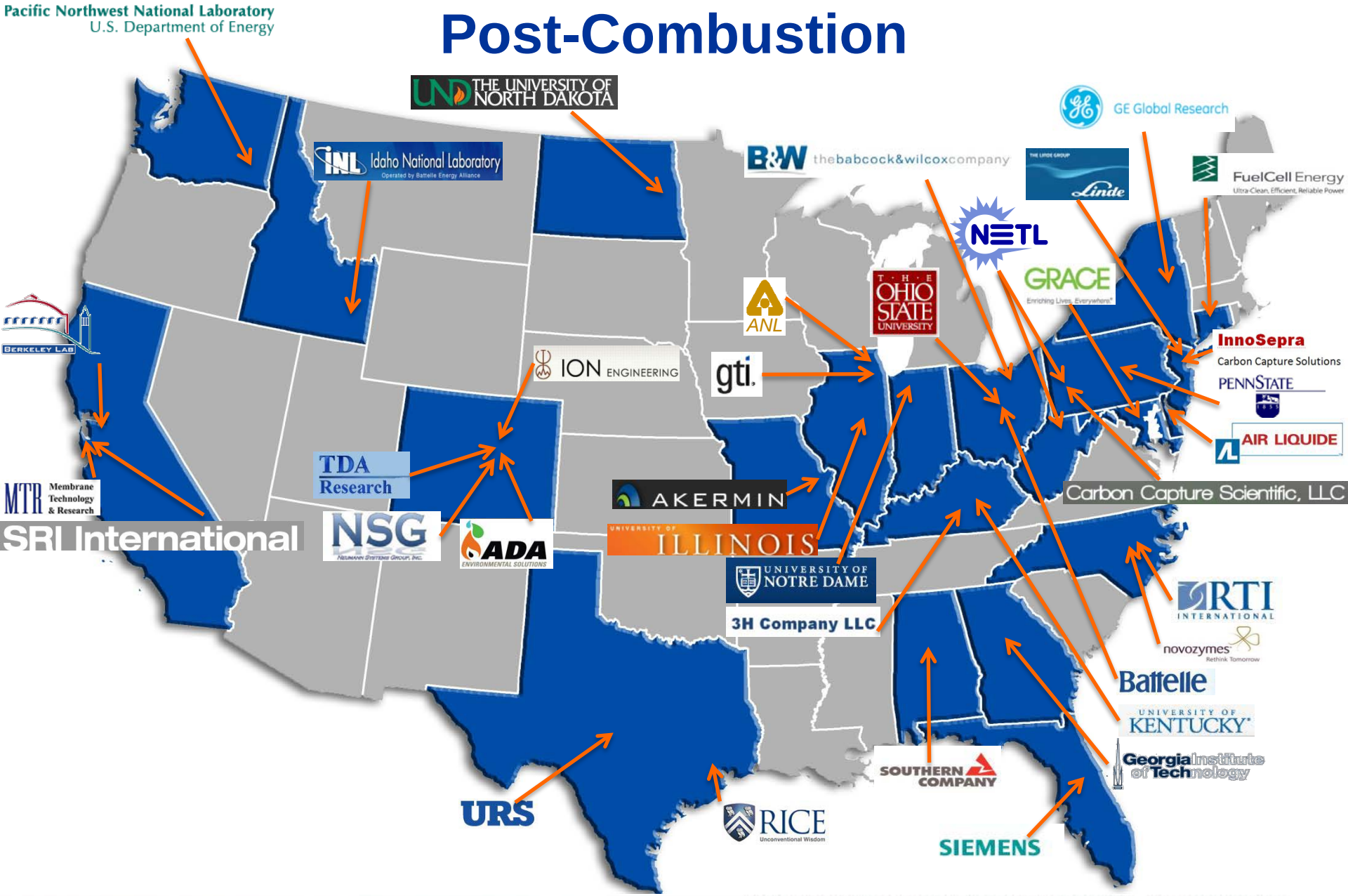
Pilot Scale

- > 0.5 MWe

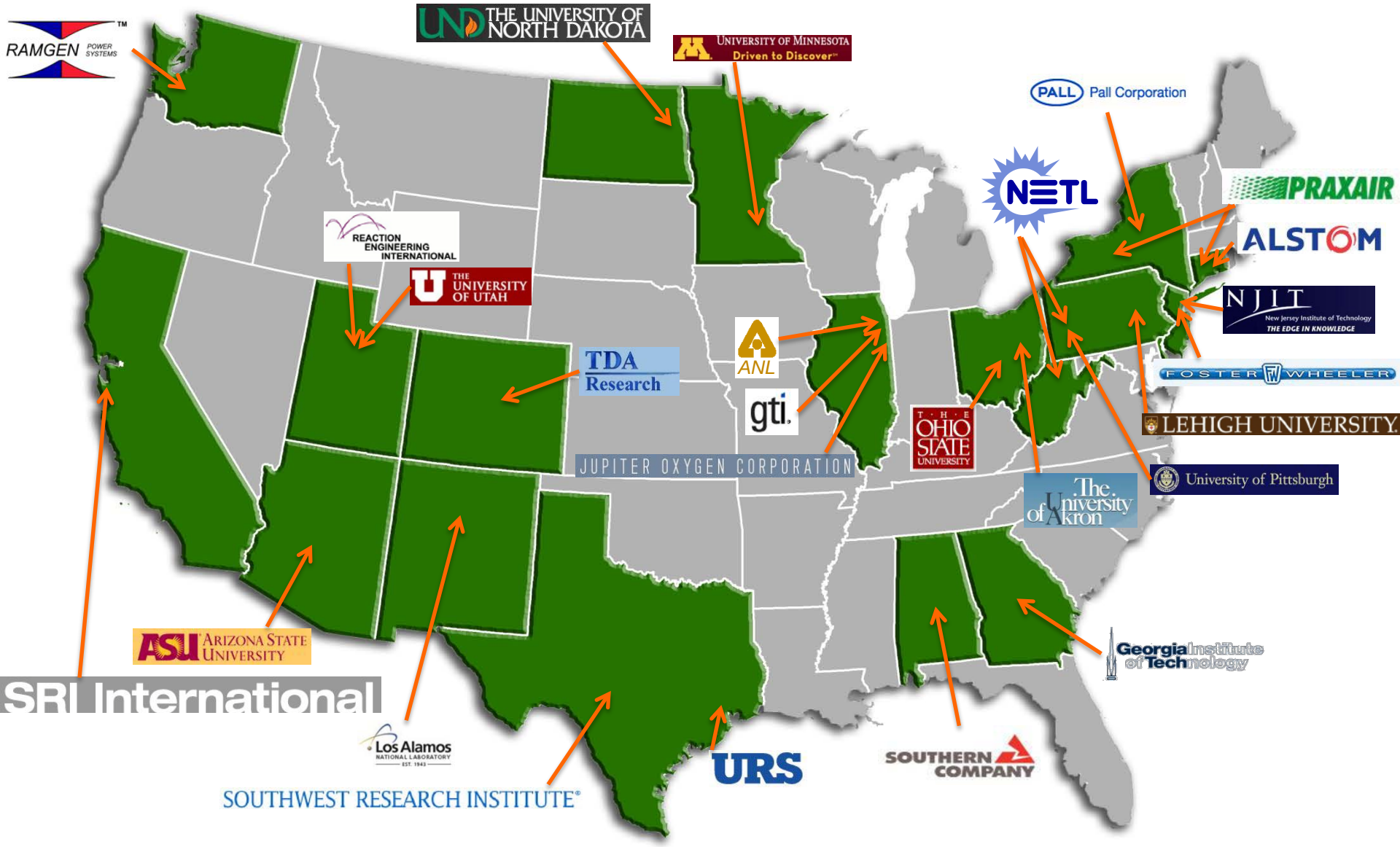
Ramgen 13,000 hp

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 CO_2 – 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:

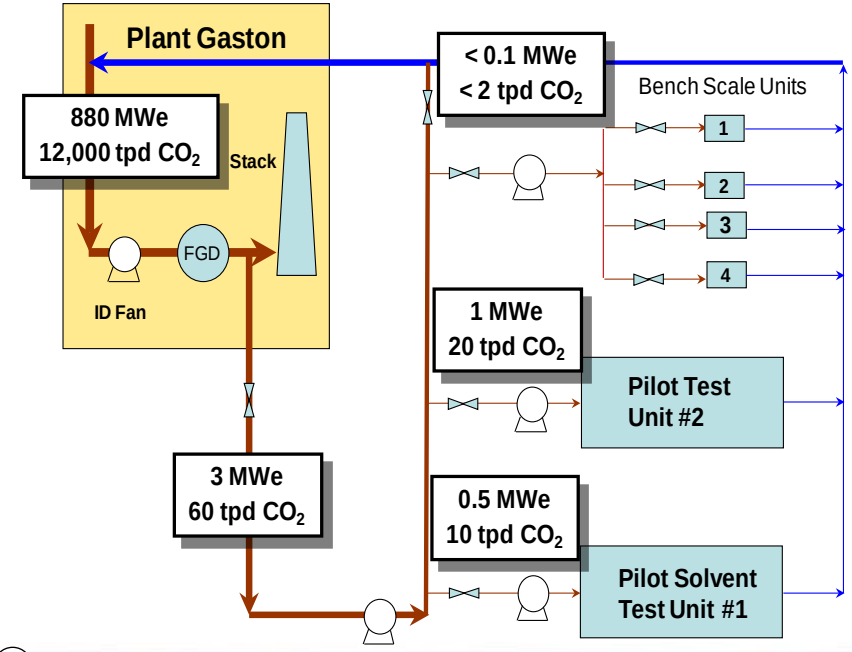
Managed by Southern Company Services, Inc.

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

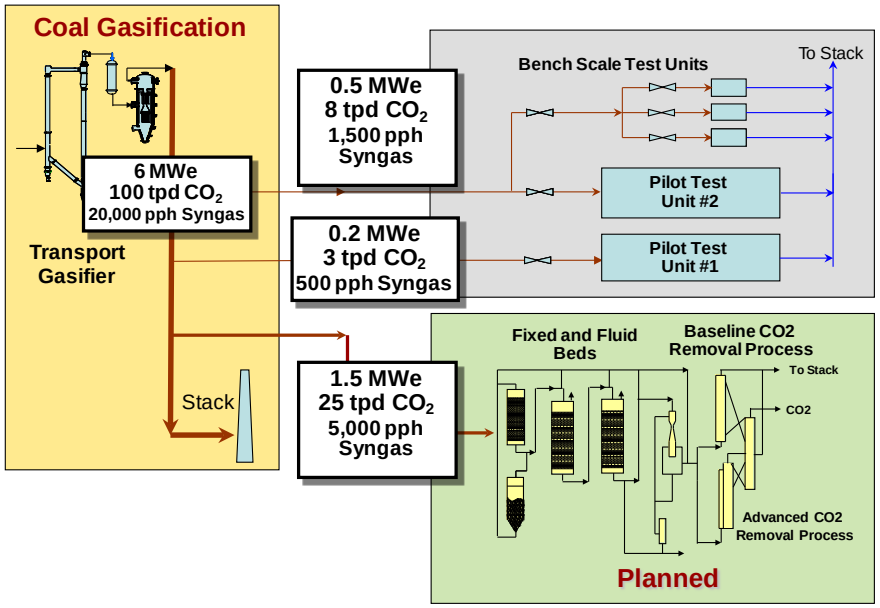
Goal

Develop technologies under realistic conditions that will reduce the cost of advanced coal-fueled power plants with CO_2 capture

Post-combustion



Pre-combustion (IGCC)



CO_2 Capture Program Goals

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

Post- and Oxy-combustion
90% CO_2 capture
Compression, transport, storage
< 35% increase in COE

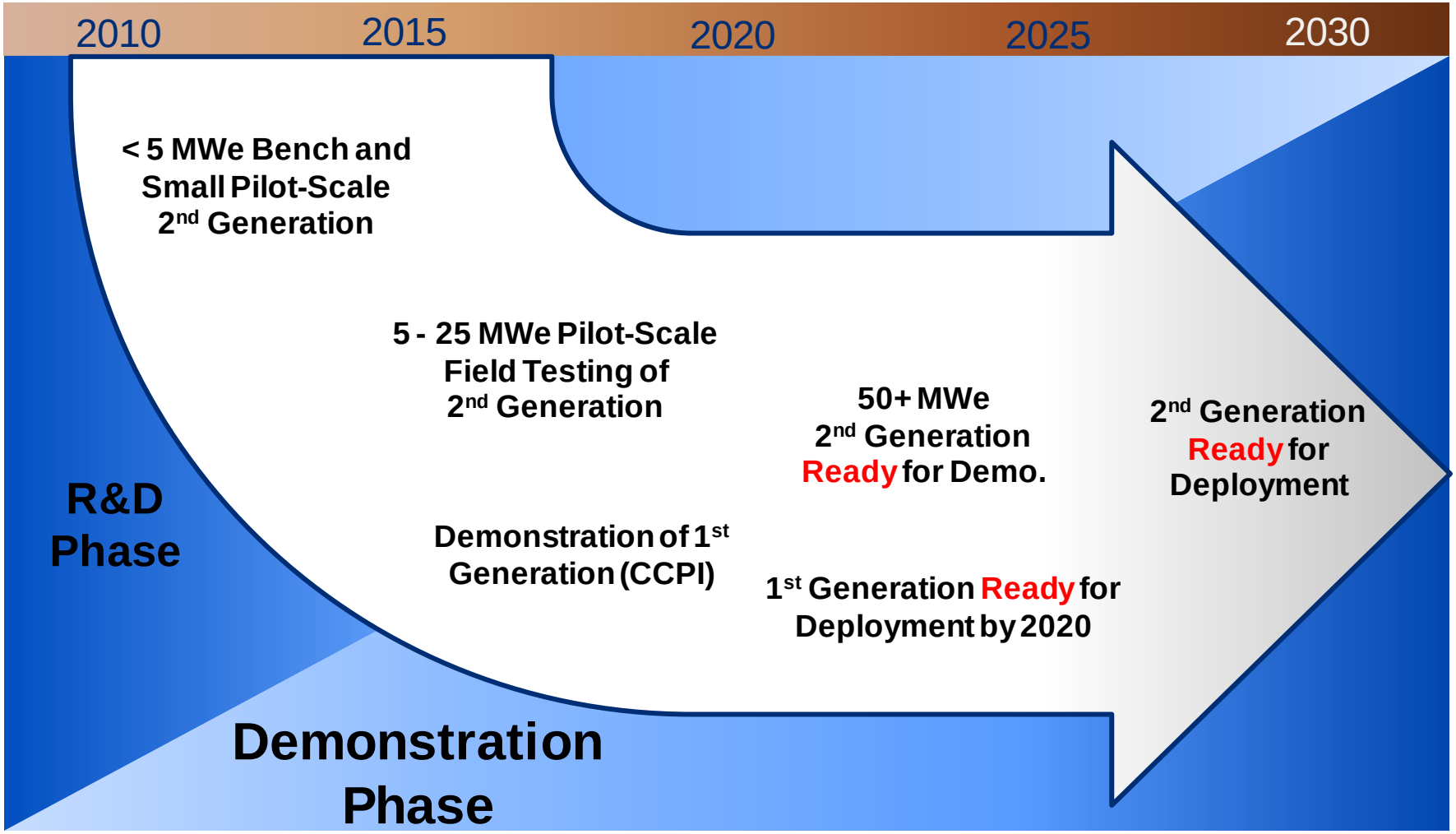
Pre-combustion (IGCC)
90% CO_2 capture
Compression, transport, storage
< 10% increase in COE

Market-Based Approach

Putting CO_2 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 CO_2 to higher value chemicals
  - Deliver advanced higher performance coal-fueled energy systems that can compete with NGCC

DOE/NETL CO_2 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"*

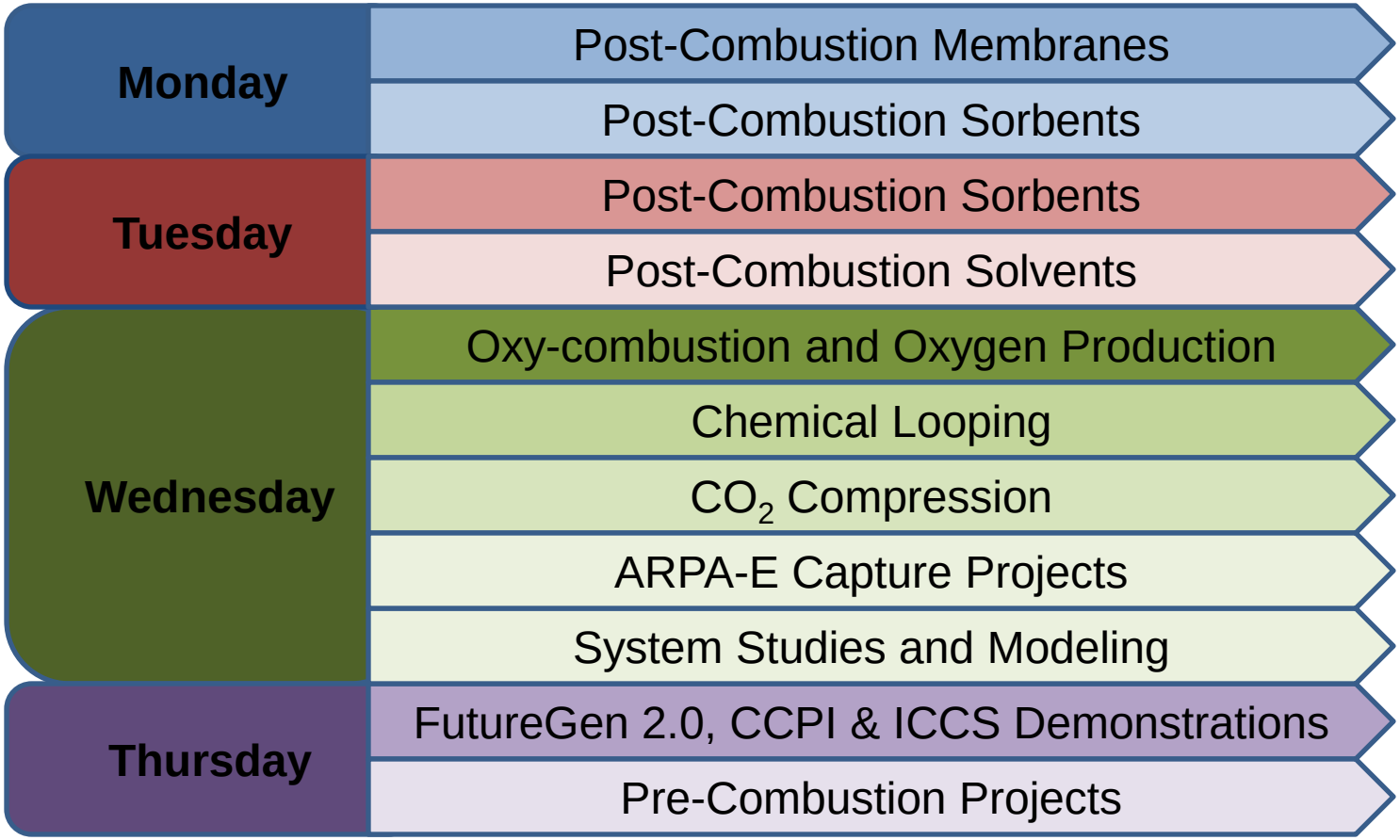
- Fall 2012/Winter 2013- FOA scheduled for release

- Summer 2013 - Project selections

- Total funding available - ~$30 million

- **Areas of Interest: TBD**

Conference Overview



Thanks for Participating!!

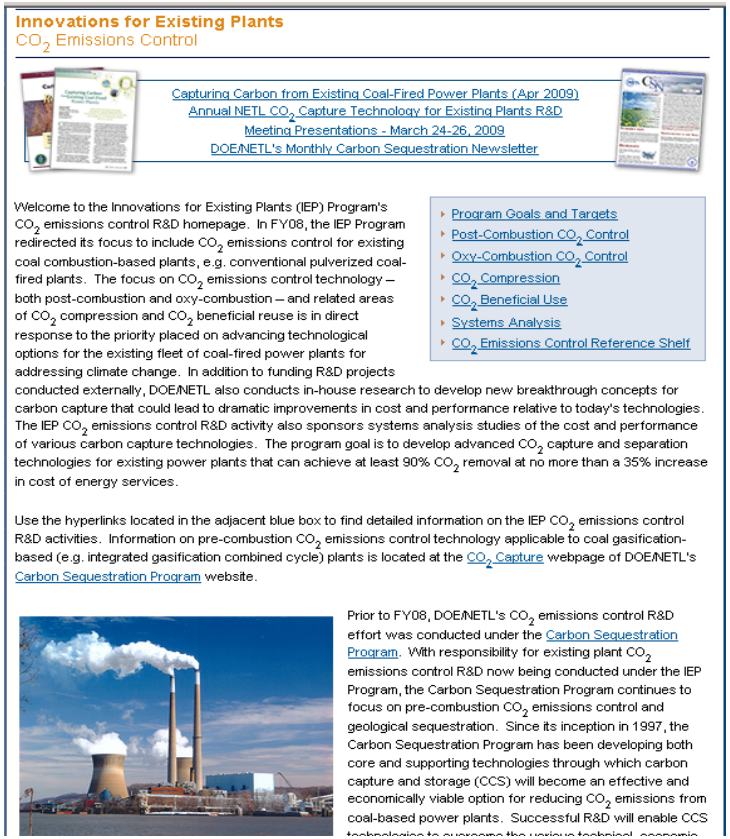

For More Information About the NETL Carbon Capture Program

- **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