Carbon Capture 2020 Workshop

October 5-6, 2009
Univ. of Maryland

DOE/NETLs Existing Plants
CO₂ Capture R&D Program

Jared Ciferno
Existing Plants Technology Manager
Existing Plants Program Structure

Post-Combustion CO₂ Capture
- Advanced Solvents
- Solid Sorbents
- Membranes
- Oxy-combustion
- Compression

Water Minimization
- Advanced Cooling
- Non-traditional Sources
- Reuse & Recovery

Mercury
U.S. Electricity Generation
CO₂ Emissions Forecast

- **Existing Coal**
- **New Coal**
- **Natural Gas**
- **Petroleum**

Values Calculated from Energy Information Administration’s Annual Energy Outlook ARRA Reference Case Scenario, AEO Does not consider PC with CCS
IEP Capture Program Budget & Partners

**IEP CO₂ Capture Annual Budget**

<table>
<thead>
<tr>
<th>Year</th>
<th>CDP</th>
<th>$Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>$30</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>$33</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>$41</td>
<td></td>
</tr>
</tbody>
</table>

**FY09 Budget Allocation**

- **Program** $4 MM
- **Sorbsents** $5 MM
- **Solvents** $5 MM
- **Membranes** $4 MM
- **Compression** $2 MM
- **Oxycombustion** $13 MM

**Industry**
- GE Research Corporation
- Praxair
- Air Products
- Jupiter Oxygen
- Alstom Power
- Babcock and Wilcox
- Foster Wheeler
- UOP
- ADA-Environmental Services
- TDA
- React Engineering International

**Laboratory**
- Lawrence Berkeley National Lab.

**University**
- Ohio State
- Georgia Tech.
- University of Notre Dame
- University of Akron
- University of Pittsburgh
- West Virginia University
- Carnegie Mellon University
- Penn State University

**Non-Profit**
- Illinois St. Geological Survey
- Research Triangle Institute
- Southern Research Institute
- SRI International
- Southwest Research Institute

CDP = Congressionally Directed Projects
Program $-Systems Analysis, Program Planning
Deployment Barriers for CO$_2$ Capture on New and Existing Coal Plants Today

1. **Scale-up**
   - Current PC capture ~200 tons/day
   - 550 MWe plant produces 13,000 tons/day

2. **Energy Demand**
   - 20% to 30% ↓ in power output

3. **Cost**
   - Increase Cost of Electricity (COE)

4. **Regulatory framework**
   - Transport — pipeline network
   - Storage
**Existing Plants CO₂ Capture Program Mission**

*By 2020, have available for commercial deployment, technologies that achieve: 90% CO₂ capture < 35% increase in COE* |

---

**Set by Systems Analyses**

---

**Evaluated by Systems Analyses**

---

*Cost of Electricity includes 50 mile pipeline transport and saline formation storage, 100 years of monitoring*

---


Existing Plants, Emissions & Capture Program—Setting Program Goals, U.S. DOE/National Energy Technology Laboratory, Final Report, April 2009
RD&D Timeline to Commercial Deployment

Laboratory-Bench Scale R&D

2008

Pilot-Scale Field Testing
0.5 — 5 MWe

2010

Large-Scale Field Testing
5 — 25 MWe

2012

*Solvents/Sorbents
*CO₂ Membrane (2012)
*O₂ Membrane (2011)

2016

Large Demonstrations (CCPI) 100+ MWe

*Solvents/Sorbents
*CLC (2016)
*O₂ Membrane (2016)

Commercial Deployment

2020

- NCCC
- Utility sites

2024

NATIONAL ENERGY TECHNOLOGY LABORATORY
For More Information About the NETL Existing Plants Program

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

Reference Shelf
- Annual CO2 Capture Meeting

Jared P. Ciferno
Technology Manager,
Innovation for Existing Plants
National Energy Technology Laboratory
U.S. Department of Energy
(Tel) 412 386-6002
jared.ciferno@netl.doe.gov

Innovations for Existing Plants
CO2 Emissions Control

Prior to FY08, DOE/NETL'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 EP Program, the Carbon Sequestration Program continues to focus on pre-combustion CO2 emissions control and geological sequestration. Since its inception in 1987, the Carbon Sequestration Program has been developing and adapting technologies through which carbon capture and sequestration (CCS) will become an effective and economically viable option for reducing CO2 emissions from coal-fired power plants. Successful R&D will enable CCS...
Department of Energy

Carbon Capture 2020 Workshop

A joint effort: Fossil Energy and Basic Energy Science

Held October 5-6, 2009
University of Maryland
Purpose of the Workshop

• Bring together researchers from industry, universities, DOE national laboratories, and other federal agencies and laboratories to discuss a broad spectrum of carbon capture research.

• Accelerate development of the best ideas for carbon capture within various time frames including near term (through 2020). Long term (i.e., 2020+) covered at a future BES led workshop.

• Identify areas for collaboration across the Office of Fossil Energy (FE) and the Office of Science’s Basic Energy Sciences (BES) carbon capture projects.
Workshop Goals

1. Communicate the current status of carbon capture technologies and so the research community understands
   - The scale and nature of the problem that needs to be addressed
   - What parameters need to be defined for research activities
   - The potential of new ideas emerging from basic research
   - The status of existing carbon capture research

2. Produce a roadmap for a coordinated effort that will impact carbon capture by 2020
   - Identify ongoing research projects that could be connected to applied research goals.
   - Propose and critique a numeric modeling approach to quickly assess the full-scale performance of new concepts
Workshop Breakout Sessions

- Breakout session discussions were designed to identify ongoing BES and FE carbon capture research activities, as well as other potential research ideas
  - Evaluate the technical readiness level of the idea, and place the idea on the technology development “ladder” (next slide).
  - Identify technical challenges that must be addressed to raise the technology readiness level (move up the ladder)
  - Propose approaches to quickly move the technology readiness up the “ladder” (e.g., modeling and analysis, as well as experiments)
  - Identify common themes (crosscutting research) to advance technology readiness of carbon capture concepts
Technology Development “Ladder”

- **Basic Science & Ideas**
- **Applied Science**
- **Engineering Science** (reactors/components)
- **System Engineering** (process & integration)
- **Pilot scale test**
- **Actual Power plant**
- **1->1000 power plants in US**

Increasing Technology Readiness Level

- **Research activity**
- **Hole to fill**
Results of workshop – a few observations

• Some technologies require going down the ladder:
  – e.g.: oxy-fuel is at the system engineering level – but we may need fundamentals on trace species, corrosion, etc.

• A key theme: need better definition of needed/desired capture performance (see next slide).

• A modeling approach to scale-up:
  – Desire to also predict operating issues (durability, trace impurity impacts…etc.)
  – Cuts across all the Technology Readiness Levels.
  – Significant existing potential and opportunities for development.
Technical Barrier: Lack of a Common Measure (from the membranes breakout session)

• A technical barrier: lack of a common measure of ranking or identifying how far new materials are from optimum.
  – Define a common measure for ranking or identifying how far the new materials are from optimum

**NOTICE THAT THE MEASURE DEPENDS ON THE PROCESS! Both process innovations and technology innovations matter!**
Common Research Themes

- Optimization algorithms and methods for complex plants – can we go faster, higher, further?
- Measurement of trace species interactions.
- Ability to measure and understand key thermodynamic, chemical, and structural characteristics – e.g., can we make lab measurements that provide the needed engineering parameters?
- Discovery of entirely new materials
- High performance computing/modeling/simulation to accelerate scale-up
Next Steps

• All the introductory and breakout session presentations, agenda, list of participants, and other relevant materials from the Carbon Capture 2020 workshop are on the NETL website.

• Host a second workshop, to be sponsored by BES, in early 2010 to identify additional novel, innovative approaches to capturing CO$_2$ for beyond 2020.

• Develop a carbon capture technology roadmap for a coordinated effort between FE and BES that will accelerate development of CO$_2$ capture technologies by 2020 (work in progress).

• Already done: start of real interaction between FE and BES funded EFRC (personnel exchanges initiated)