Symposium on the Global Energy Future

Coal III: Panel Discussion
R&D Needs for Future Clean Utilization of Coal

October 4, 2010
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Coal Utilization Research Council
www.coal.org
Currently Proposed and Forecasted Coal-Fired Capacity

- Aging U.S. coal fleet
- High construction costs on new builds
- Successful environmental opposition to coal
- Natural (shale) gas supplies

No Forecasted Coal Plant Additions for 10 Year Period, Few Additions for Next 15 Years and Very Low Future Additions

Source: NETL
Proposed U.S. New Capacity
Coal, Natural Gas, Wind, and Nuclear

Source: NETL
The Importance of CCS

- Without new policies, global emissions increase by 130% by 2050, leading to a 4-7°C temperature rise.
- CCS provides one-fifth of the needed CO₂ reductions in 2050.
- Without CCS, the cost of stabilization rises by 70%.
- CCS is the only low-carbon solution for gas/coal, cement, and iron & steel sectors, etc.
<table>
<thead>
<tr>
<th>Criteria Pollutants</th>
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<tbody>
<tr>
<td>Hazardous Pollutants (HAPS) -- Mercury</td>
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Water & Waste

Greenhouse Gases
Carbon dioxide, etc.
Renewable Portfolio Standards

www.dsireusa.org / March 2010

29 states + DC have an RPS
(6 states have goals)

- Renewable Portfolio Standards
- State renewable portfolio standard
- State renewable portfolio goal
- Solar water heating eligible

<table>
<thead>
<tr>
<th>State</th>
<th>Renewable Portfolio Standard</th>
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<tbody>
<tr>
<td>WA</td>
<td>15% x 2020*</td>
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<tr>
<td>OR</td>
<td>25% x 2025 (large utilities)*</td>
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<td>OR</td>
<td>5% - 10% x 2025 (smaller utilities)</td>
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<tr>
<td>NV</td>
<td>25% x 2025*</td>
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<tr>
<td>CA</td>
<td>33% x 2020</td>
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<td>AZ</td>
<td>15% x 2025</td>
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<tr>
<td>HI</td>
<td>40% x 2030</td>
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<tr>
<td>CO</td>
<td>20% by 2020 (IOUs)</td>
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<td></td>
<td>10% by 2020 (co-ops &amp; large munis)*</td>
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<tr>
<td>MT</td>
<td>15% x 2015</td>
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<tr>
<td>MN</td>
<td>25% x 2025</td>
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<tr>
<td></td>
<td>(Xcel: 30% x 2020)</td>
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<td>ND</td>
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<td>SD</td>
<td>10% x 2015</td>
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<td>WI</td>
<td>Varies by utility;</td>
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<tr>
<td></td>
<td>10% x 2015 statewide</td>
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<tr>
<td>IA</td>
<td>105 MW</td>
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<tr>
<td>MI</td>
<td>10% x 2015 + 1,100 MW</td>
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<td></td>
<td>x 2015*</td>
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<td>TX</td>
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24 States have Greenhouse Gas emissions targets
White House and Congressional support for nuclear & renewables is intense

• Examples:
  – The FY 2011 DOE budget request –
    • All energy sectors (renewables, nuclear) received requested increases in budgets, coal did not, more tax incentives
  – $130 billion in loan guarantees available or requested
    • $56 billion for nuclear
    • $65 billion for renewables & transmission
    • $ 8 billion for coal with CCS
Important Advantages of Natural Gas

• NGCC -- relatively low capital costs, short construction time, low environmental impacts, economical at moderate scale.
  – Allows owners to closely follow increases in demand & reduces likelihood of overbuilding
  – CO₂ emissions per kWh about 1/2 that of coal
  – Technology is mature, reliable, and dispatchable
Issues Related to the Use of Natural Gas

- Natural gas requires CCS to meet aggressive climate goals
  - Raises costs
  - Issues common to coal with CCS
  - NETL estimates increased cost of CCS for NGCC vs SCPC is $29/MWh vs $55/MWh

- The price and availability of natural gas is more uncertain than for other fuels.
EIA projects Shale gas gains to offset conventional gas losses over the next 12 years

Shale gas and Alaska pipeline gas offset declines in conventional supply

Source: USDOE/EIA AEO-2010.
EIA estimated typical COE for AEO2010

NOTE: Average Wholesale COE in 2007 was 57 $/MWh

NGCC is clearly cheaper at assumed gas price and w/o CCS.
New Plants R&D Goals for 2nd Gen CCS Systems

**Key Assumptions:**
- 30 year, current dollar levelized coe; December 2009 dollars
- Capital cost component includes owner’s costs
- $1.64/MBtu coal price
- “R&D Progress to Date” cases based on DRAFT Rev 2 of Bituminous Baseline Study
- “2nd Gen IGCC w/CCS” case based on NETL’s IGCC Pathway study, upgraded to incorporate more complex Rev 2 Bit. Baseline study costing methodology

**TIT** = turbine inlet temperature  
**WGCU** = warm gas cleanup  
**ITM** = ion transport membrane  
**USC** = Ultra supercritical  
**FGD** = Flu Gas Desulfurization

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**Today’s New IGCC w/o CCS = $109/MWh**

- 7FB turbine (2400 F TIT)
- 80% Availability

**Today’s New Supercritical PC w/o CCS = $85/MWh**

- Air-fired
- 3500 psig/1100F/1100F
- Wet FGD
- Amine absorber for CO₂ separation
- 85% Availability

**2nd Gen IGCC w/CCS**

- Coal pump
- WGCU
- H₂ membrane
- ITM
- Adv H₂ turbine-2 (2650 F TIT)
- 1 on 1 configuration
- 90% Availability

**2nd Gen Advanced Oxy-Combustion PC w/CCS**

- Oxy-fired combustion
- Boiler-integrated ITM
- USC steam cycle (4000 psig / 1350F / 1400 F)
- Compact oxyfuel-specific boiler
- SO₂ co-sequestration
- 90% Availability

**2nd Gen Advanced Post-Combustion PC w/CCS**

- Advanced solvents, sorbents or membranes
- USC steam cycle
- Advanced CO₂ compression
- 90% Availability

**Source:** US DOE
Existing Plants
R&D Goals for 2nd Generation CCS Systems

Key Assumptions:
- 30 year dollar levelized COE; December 2009 dollars
- Capital cost component includes owner’s costs
- “Existing PC Plant Marginal Cost Range” based on Energy Velocity Dataset for the USA PC plant fleet; assumes all capital costs have been recovered
- “SOA CCS Retrofit” case based on NETL’s CCS retrofit Study (Nichols, et al), upgraded to incorporate more complex Rev 2 Bit. Baseline study costing methodology
- Assumes 15% energy penalty; adds 75% of +$25/MWh “delta” from SCPC Greenfield w/CCS; and adds 30% of +$25/MWh for retrofit cost allowance

Source: US DOE
Transition Strategy

World has changed in last 18-20 months

• Climate legislation will not happen – soon
• Congress & Administration favor ABC
• The abundance of shale gas
• The march of state level RPS & GHG restrictions
• Global recession & drop in demand
• Few if any new coal power plants
More thoughts on where we are

• Major cost reductions only possible with a combination of continued R&D and “learn by doing” demonstrations
• “Breakthroughs” are possible, cannot be predicted
• A carbon price signal may be important but unrealistic deadlines are counterproductive – potential users abandon technology improvement process and dedicate resources to compliance.
• A clear RD&D plan to move technology forward even without a carbon price signal is essential
• Deployment projects beyond first-of-a-kind are needed before industry will adopt new technology
Elements of a Transition Strategy

- Support 5 to 10 commercial-scale demonstrations by 2016 and then full scale deployment based upon a carbon price? Role of oxy-fuel as FutureGen 2.0
- A power sector bridge program to maintain momentum & technology teams (support FEEDs & CO2 site characterization projects)
- Renew efforts to increase plant efficiency as a near-term pathway to CO2 reductions
- Develop less expensive retrofit technology
- Seek loan guarantees, clarifications to tax credits and direct funding/grants (including the “wires charge”)
- Address EPA rules on criteria pollutants and HAPs
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