The Path Forward for Coal
The Role of Technology Innovation

Janet Gellici, National Coal Council
Power Plant Management & Generation Summit
Houston, TX – October 24, 2016
The National Coal Council provides advice and recommendations to the Secretary of Energy on general policy matters relating to coal and the coal industry.

NCC is a Federal Advisory Committee organized under FACA legislation.
National Coal Council

**Members**

Appointed to serve by Secretary of Energy

125-150 members

- **Industry** – coal suppliers, utility & industrial consumers & coal transportation
- **Support Services** – engineering firms, vendors, consultants & attorneys
- **Academics**
- **NGOs** – environmental & trade association reps
- **Government** – PUC & state energy officials

**Reports**

~ 35 reports prepared by NCC members at no cost to DOE

**Extensive Range of Topics**

- Carbon Management
- Clean Coal Technologies
- Coal & Coal Technology Exports
- Coal Conversion
- Utility Deregulation
- Climate & Clean Air Regulations
- Building New Coal Power Plants
- Industrial Coal Use
- CCUS for EOR
- Value of Existing Coal Fleet
- Fossil Forward: CCS Technologies
- Policy Parity for CCS
- CO₂ Building Blocks: CO₂ Utilization
Presentation Overview

- Trending in Energy
- Policy Parity for Coal Technologies
- The Path Forward
Trending in Energy

- Integration of Fossil Energy
- “Expanding the Tent”

Common & Distinct Challenges of Carbon Capture for Coal & Natural Gas

Source: U.S. Department of Energy
Trending in Energy

- Technology Innovation Push
- International Partnerships

MISSION INNOVATION
Accelerating the Clean Energy Revolution

nrg & cosia CARBON XPRIZE
Reimagine CO₂

U.S.–CHINA CLEAN ENERGY RESEARCH CENTER
中美清洁能源联合研究中心

INTRODUCING THE BREAKTHROUGH ENERGY COALITION
The world needs widely available energy that is reliable, affordable and does not produce carbon.
Trending in Energy

- Energy Security
- Value of Diversity

“A diverse portfolio of energy resources is critical to U.S. energy and national security. A diverse energy system has the inherent benefits of being more robust and resilient in comparison to a system that is heavily dependent on a limited set of energy resources. A system that is diverse helps insulate the economy from certain risks, including price volatility and risks from supply disruptions that can affect the availability of particular energy resources or infrastructure.”

U.S. Department of Energy – August 2016
Carbon Capture, Utilization, and Storage: Climate Change, Economic Competitiveness, and Energy Security
Consensus on Need for CCUS
Recognition of Need for Policy Parity for CCS

“There is a growing consensus among industry, the environmental community and governments that future carbon dioxide (CO₂) emission reduction goals cannot be met by renewable energy sources alone and that carbon capture, utilization and storage (CCUS) technologies for all fossil fuels will have to be deployed to achieve climate objectives in the U.S. and globally.”

National Coal Council – August 2016
CO₂ Building Blocks: Assessing CO₂ Utilization Options

“In order to achieve CCS deployment at commercial scale, policy parity for CCS with other low carbon technologies and options is required.”

National Coal Council – January 2015
Fossil Forward – Revitalizing CCS: Bringing Scale & Speed to CCS Deployment
FOSSIL FORWARD
Revitalizing CCS
Bringing Scale and Speed to CCS Deployment

NCC Report - January 2015
Policy Parity
for Carbon Capture and Storage Technologies

LEVELING THE PLAYING FIELD
Dis-Parity CCS vis-a-vis Renewables

Global Clean Energy Investments
2004 - 2013

Renewables*
$1,929 Billion

Carbon Capture & Storage
$20 Billion

Source: International Energy Agency. *Includes technology development, projects, M&A. Source: BNEF.
U.S. Renewables Received 12X Federal Incentives Versus Coal in 2013

Renewables Receive 72% of Total Incentives
Coal Just 6%

- Fossil fuels produced 78.5% of U.S. energy; renewables 11.4%, nuclear 10.1% in 2013
- Renewable subsidies increased from ~15% in 2007 to 72% in 2013
- Funding for coal declined from 12.7% in 2007 to 6% in 2013

U.S. Energy Incentives in 2013

- $13.22 Billion
- Coal $1.08
- Renewables $13.22 Billion

Source: Energy Information Administration, March 2015.
Policy & Financial Incentives Work
Capital and operating costs for projects with CCS are more expensive than conventional technologies, carrying greater commercial risk.
The Path Forward - Leveling the Playing Field

Financial Incentives
• Broaden to include incentives available to other clean energy sources

Regulatory Improvements
• Regulatory blueprint needed to remove barriers to construction and development of CCS projects

Research Development and Demonstration
• U.S. Dept. of Energy must be a catalyst for commercial scale demonstrations to start immediately

Communications and Collaboration
• U.S. Dept. of Energy must assure policymakers that fossil fuels will continue to be used & CCS is essential
Recommendations for Leveling the Playing Field

Foundational Financial Structure: Contracts for Differences

- Establish a “contracts for differences” structure enabling greater competitiveness
- Allow developers to propose a menu of government incentives – e.g., CCPI grants to reduce capital, loan guarantees to reduce borrowing costs, tax credits to reduce cost of power over time
- Provide CFD structure for first 5-10 GW of projects with CCS on a competitive basis
- Use to create commercial demonstrations and large-scale pilot projects
Recommendations for Leveling the Playing Field

Financial Incentives

• **Limited Guaranteed Purchase Agreements**: Offer a limited number of pioneering CCS facilities to receive a guarantee that their output will be purchased in order to obtain financing

• **Market Set Aside**: Establish a market set-aside to provide parity with state RES requirements

• **Clean Energy Credits**: Allow CCS projects to receive credit under applicable programs for 100% of CO$_2$ emissions avoided
Recommendations for Leveling the Playing Field

Financial Incentives

• **Tax Credits and Price Interventions**: In addition to guaranteed purchase agreements and the ability to attract financing, offer other support through:
  – Production Tax Credit
  – Revised CO$_2$ Injection Credit
  – Electricity Price Stabilization
  – CO$_2$ Price Stabilization

• **Tax-Preferred Bonds**: Provide financing with tax-preferred and tax exempt bonds under Section 54 or Section 142 of Internal Revenue Code
Recommendations for Leveling the Playing Field

Financial Incentives

• **Master Limited Partnerships**: Provide MLP structure for projects with CCS so qualifying income is taxed at the individual level

• **Loan Guarantees**: Put in place a mechanism to pay the credit subsidy cost of loan guarantees similar to the Section 1705 program that helped renewables
**CO₂ Reduction Glidepath**

**Increasing Efficiency of Coal Plants by 1% Reduces CO₂ 2-3%**

- **Average Worldwide**
  - 30%
  - 1,116 g CO₂/kWh

- **EU**
  - About 38%
  - 881 g CO₂/kWh

- **State-of-the-art technology**
  - 45%
  - 743 g CO₂/kWh

- **Gas OCGT**
  - 480-575 g CO₂/kWh

- **Gas CCGT**
  - 340-400 g CO₂/kWh

- **Steam power plant 700°C technology**
  - About 50%
  - 669 g CO₂/kWh

- **CCS technology but efficiency loss 7-12% points**

Source: VGB PowerTech 2013, World Coal Association.
Horizon Technologies

Advanced Supercritical Longview

Rare Earth Elements

The Allam Cycle

Iron+Power+Steel

Chemical Looping
“One of the greatest challenges we face and a potential game changer is how we can develop technologies for very, very, very large-scale utilization of CO₂.”
Secretary Moniz – House Testimony – September 15, 2016
CO₂ Building Blocks
Assessing CO₂ Utilization Options

Key Finding
CO₂-EOR still represents the most immediate, highest value opportunity to utilize the greatest volume of anthropogenic CO₂.

<table>
<thead>
<tr>
<th>Basin/Area</th>
<th>Technically Recoverable Oil (Billion Barrels)</th>
<th>Technical CO₂ Demand/Storage (Million Metric Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technically</td>
<td>“Next Generation”</td>
</tr>
<tr>
<td>Main Pay Zone CO₂-EOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower-48 Onshore</td>
<td>55.6</td>
<td>105.5</td>
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<tr>
<td>Alaska</td>
<td>5.8</td>
<td>8.8</td>
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<tr>
<td>Offshore GOM</td>
<td>23.5</td>
<td>52.9</td>
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<tr>
<td>Sub-Total</td>
<td>84.9</td>
<td>167.2</td>
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<tr>
<td>Residual Oil Zone CO₂-EOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROZ Fairways*</td>
<td>n/a</td>
<td>25.7</td>
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<tr>
<td>Below Oil Fields</td>
<td>n/a</td>
<td>16.3</td>
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<tr>
<td>Sub-Total</td>
<td>n/a</td>
<td>42.0</td>
</tr>
<tr>
<td>Total</td>
<td>84.9</td>
<td>209.2</td>
</tr>
</tbody>
</table>

*Four County Permian Basin San Andres ROZ fanway.
**CO₂ Geologic Markets**

- **SHALE GAS**: Shale gas formations offer potential to store large amounts of CO₂ while increasing recoverable reserves of natural gas.

- **ENHANCED COAL BED METHANE**: ECBM has potential to store CO₂ and recovered methane can be used as a fuel that could supplement coal and oil with far lower CO₂ emissions when combusted.

- **ENHANCED WATER RECOVERY**: EWR presents a major opportunity for new sources of water in an increasingly water-scarce world.

- **GEOTHERMAL STORAGE**: Potential to use heat in geological brine to generate electricity by harnessing geothermal energy.
**CO₂ Markets – Non-Geologic**

**Two Pathways to CO₂ Non-Geologic Utilization**

- Cleaving - Breaking down the CO₂ molecule by cleaving C=O bond(s)
- Intact/Fixed - Incorporating the entire CO₂ molecule into other chemical structures
CO₂ Non-Geologic Markets

- INORGANIC CARBONATES & BICARBONATES: Includes carbon products (carbon black, activated carbon, nanofilters, graphene); cement & aggregates; buffers & other chemical products (baking soda, potassium bicarbonate)

- PLASTICS & POLYMERS: Includes polymers and fine chemicals.

- ORGANIC & SPECIALTY CHEMICALS: Includes urea, ethylene & propylene, DMC, acrylic acid and solvents.

- AGRICULTURAL FERTILIZERS: A source of high efficiency carbon and oxygen food for plants and trees with ability to balance nitrogen.

Key Finding

Some non-geological CO₂ utilization options are promising in that they tend to “fix” CO₂.
CO₂ Non-Geologic Markets

- **FOOD & BEVERAGE**: Includes beverage carbonation and production of dry ice.
- **FUELS**: Includes methanol, hydrocarbon fuels and biological processes (algae/microrganisms).

### Order of Magnitude Estimates for the Worldwide Capacity of CO₂ Utilization

<table>
<thead>
<tr>
<th>Option of CO₂ Utilization</th>
<th>Worldwide Capacity (Order of Magnitude in Giga Ton Carbon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-chemical Utilization</td>
<td>0.01 – 0.1 GtC per year</td>
</tr>
<tr>
<td>Chemicals &amp; Materials</td>
<td>0.1 – 1 GtC per year</td>
</tr>
<tr>
<td>Synthetic Liquid Fuels</td>
<td>1 – 10 GtC per year</td>
</tr>
</tbody>
</table>

Source: Song, 2002

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**Key Finding**

All non-geological CO₂ utilization options should be lifecycle analyzed and assessed for their potential to store CO₂ on a permanent basis.
CO$_2$ Markets as Incentives for CCUS

- U.S. law recognizes CO$_2$–EOR and other geologic storage technologies for compliance purposes.
- Non-geologic storage technologies may be used only if EPA determines they are as effective as geologic storage.
- U.S. climate goals and non-binding international climate goals require CCUS technology deployment at scale in the near future.
- CO$_2$ utilization in non-geologic contexts face the following hurdles:
  - Cost of capture
  - Insufficient scope of market/supply
  - Nearly all non-geologic CO$_2$ utilization technologies are not yet commercialized
  - Geographic/infrastructure considerations
  - Legal and regulatory considerations
Janet Gellici, CEO
jgellici@NCC1.org
www.nationalcoalcouncil.org