Kentucky Carbon Sequestration Activities and the National Research Council Recommendations for Coal Research Priorities

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State Geologist and Director

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June 2, 2008

• US Senate begins battle over carbon dioxide control and regulation

• Sen. Majority Leader Harry Reid (D Nev.)- “it is clear global warming is real and Congress must act.”

• Sen. Minority Leader Mitch McConnell (R Kent.)- “this is a tax on virtually every aspect of the economy,…Democrats are laughably out of touch to take up this bill when the country is reeling from $4 gal. gasoline.”
KyHB-1 New Mechanism for Funding University

• Legislation (HB-1) as a new mechanism for funding

• Leverage $0.75 million salaries/yr at KGS

• Recruited industries to participate in funding, sites, & technical input

• Allows time to get the research done regardless of changes in state administration

• Kentucky legislators gave a signal to the nation that the perceived need for CO2 control has penetrated deeply into the American political scene, a bellwether event!

• Industry partners have formed a 501 (c) (3) foundation to manage the cost-share
HB-1 directs KGS to conduct research, either itself or in collaboration or under contract with other entities, to quantify the potential for enhanced oil and gas recovery and enhanced coalbed methane recovery using carbon dioxide. The research shall include the drilling of deep wells in both coal fields (Illinois and Appalachian) in Kentucky, and performing the analysis necessary to estimate the potential for enhanced oil and gas recovery, enhanced coalbed methane recovery, or permanent storage of sequestration of carbon dioxide.
At least one of the wells will test the Devonian shale for enhanced gas recovery and sequestration potential. The Kentucky Geological Survey is encouraged to use these funds to match available federal and private funds to the extent possible. The Governor’s Office of Energy Policy shall report to the Legislative Research Commission by December 1, 2007, regarding the status of the research project with this appropriation.
### Draft Budget for KyHB-1

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*UK is cost sharing about $1.5 M at full indirect rate of 46.5%*
Project Goals

• Demonstrate CO2 storage in deep saline reservoirs in the Illinois Basin

• Demonstrate the integrity of reservoir sealing strata for long-term CO2 storage in western Kentucky

• Demonstrate appropriate technologies for the evaluation of CO2 storage in Kentucky deep saline reservoirs

• Publish the project results for use by government, industry, and the public in evaluating CO2 storage in Kentucky

• Accomplish this project with consideration of the interests and concerns of the landowner, residents of Hancock County and western Kentucky, and the citizens of the Commonwealth
The completed CO$_2$ storage test well will be among the deepest wells drilled in western Kentucky.
Deep Rock Units in Western Kentucky

Regional saline reservoirs:

- Mt. Simon Sandstone
- Knox Group dolomites
- St. Peter Sandstone
Deep Rock Units in Western Kentucky

Just as important in an injection project are the sealing units:

- Eau Claire Formation
- Maquoketa Shale
- Ordovician carbonates
- Devonian Shales

Potential CO₂ sinks/reservoirs
- Sealing interval
- Missing section
- Sink or seal (depends on location)
- Metamorphic and igneous rocks (mostly seal)
The Knox Group is a widespread, thick unit of dominantly non-porous dolomite, but known to have several intervals of well-developed porosity.

Proposed Well KGS #1 TD 8250 ft

KGS #1: TD 8250 ft

Hickman et al., www.esri.com/mapmuseum/mapbook_gallery/volume19/environment3.html
North-South Seismic Line 7, Hancock County, showing the projected location of the proposed CO2 storage test well.
The Knox dolomites in western Kentucky have many well-developed porosity zones (red). The test well will encounter intervals of intercrystalline, vuggy, and fracture porosity.
Drilling Program

- Drill to 50 ft and cement casing to protect shallow groundwater
- Drill to 500 ft and cement casing to isolate any shallow oil and gas zones
- Drill to 3000 ft and cement casing to ensure against any possible leakage to the surface during testing
- Drill to 8250 ft to gather geological, geophysical, and geochemical data to identify and aid the design and evaluation of the intervals to be tested
Testing Program

- Testing will proceed from the deepest interval to the shallowest below casing.
- Test intervals will be isolated from deeper and shallower intervals.
- All intervals will be first tested by injection of an artificial brine.
- The most favorable interval will be tested by injection of a small volume of CO₂.
- At the completion of testing the well will be plugged and abandoned to Kentucky and EPA standards.
Western Kentucky Sequestration Project Management Structure

RELATIONSHIPS OF PARTNERS AND DIVISION OF RESPONSIBILITIES
(Dashed lines indicate oversight; solid lines indicate payment for services)
KGS #1 Wellsite Construction Program

Proposed Wellsite (1.75 Ac)

- Proposed Drilling Pad
- reserve pits
- pumps-hq
- trailers

- Culverts for drainage
- Hill
- Pond
- Total of 0.75 km (0.47 mile) gravel road needed:
  - first 1/3 needs slight upgrade
  - second 1/3 needs simple grading, compacting & gravel
  - last 1/3 is now through woods with elevation changes

- Existing hard packed dirt road
- Comaty
- Wide turn
- Wide cattle guard w/ gate

- Barns
- Historic Cemetery
- Landowner Residence

Incorporating cultural and historical respects:

- Design and construction to minimize impact on the historic cemetery.
- Ensure compliance with environmental regulations for the historic site.

Financial considerations:

- Cost estimation for site preparation and road construction.
- Budget allocation for ongoing maintenance.

Operational aspects:

- Monitoring water flow and quality post-construction.
- Safety protocols for workers near the historic cemetery.

Conclusion:

- The proposed construction plan respects cultural and environmental values.
- Additional safeguards are in place to mitigate potential impacts.
- A comprehensive monitoring program is initiated for water quality assurance.
Western Kentucky Project Timeline

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<tr>
<td>Organization</td>
<td>Site Characterization</td>
<td>EPA Permitting</td>
<td>Drilling</td>
<td>Testing</td>
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KYCCS
Project Status: Review

- The western Kentucky CO₂ storage demonstration project has progressed quickly
  - A consortium of KGS and energy industry partners has been organized
  - The project funding vehicle has been established
  - A drillsite has been identified and lease terms negotiated with the landowner and oil and gas leaseholder
  - Initial contractor service bids are under review
  - Drillsite construction is being evaluated

- Estimated commencement of operations is during the 4th Quarter of 2008 with well testing, reservoir evaluation, and final reports completed by yearend 2009

- Surface monitoring will continue through year-end 2012 until the abandonment of the well and dissolution of the consortium
Other HB-1 Projects

• Enhanced Oil and Gas Recovery
• Enhanced Devonian Gas Recovery
• Eastern Kentucky Deep Saline Reservoir
Acknowledgements

This research is supported by a consortium of more than 20 industry partners, principally ConocoPhillips, E.ON US, Schlumberger, and Peabody Energy, legal and consulting firms, and the Commonwealth of Kentucky, University of Kentucky, and the Kentucky Geological Survey.
The NRC coal report

• Focused on federal R & D on the “upstream” side of the coal industry.

• 8% of federal R & D goes for “upstream” activities in the coal cycle.

• U.S. has more than adequate reserves to accommodate this increase, R & D is needed.

• Main obstacle to future coal development is carbon management technologies.
U.S. Primary Energy Consumption by Fuel, 1960-2030 (quadrillion Btu)

History vs. Projections

- Liquid Fuels
- Coal
- Natural Gas
- Nuclear
- Renewables

EIA Annual Energy Outlook 2007 - Preliminary
Committee’s Charge

• Examine coal resource assessments, technologies, and R&D activities

• Focus on “upstream” aspects of the coal cycle – mining, processing, and transport

• Concentrate on next 25 years

• Identify critical R&D gaps

• Highlight any stumbling blocks to increased coal production

• Examine need for a coordinated and integrated multi-agency R&D program and be brief
Coal Industry an Integral Component of U.S. Economy

• Coal provides ~23% of the total energy consumed

• Coal generates over half of nation’s electricity, consuming 92% of the 1.1 billion tons of coal mined annually

• Carbon emissions policy provides the overarching context for future coal use
Coal Use Forecasts - U.S. and World

- Dominant factors affecting future coal use:
  - Feasibility of CO$_2$ control measures
  - Constraints on greenhouse gas emissions
  - Future electricity demand
  - Availability of alternative energy sources

- Until ~2020, from ~25% above to ~15% below 2004 levels

- By 2030, from ~70% above to ~50% below 2004 levels

- U.S. imports & exports small and likely to remain so

- Largest international increases in China and India; uncertainty beyond 2020
Federal Coal-Related R&D Funding
$538 million in 2005

- **Utilization & CCS**: 82%
- **Transport & Transmission**: 9%
- **Safety & Health**: 4.5%
- **Reserve Assessment**: 1.9%
- **Environment / Reclamation**: 1.8%
- **Mining and Processing**: 0.2%
Coal Fuel Cycle

RESERVES
- Western Reserves
- Interior Reserves
- Appalachian Reserves

MINING
- Surface Mining
- Underground Mining

PREPARATION
- Coal Preparation
- Processing Losses

TRANSPORT
- Rail
- Multi-mode
- Water
- Minemouth Truck

UTILIZATION
- Electricity Generation
- Coke
- Other Industry

NRC 2007

SCALES
- Tonnage represented by thickness
- Flows (Mt/yr)
- Operations (Mt/yr)
Coal Reserve and Quality Assessments

- U.S. has sufficient coal through 2030
- Probably has sufficient coal for more than 100 years at current consumption rate
- Not possible to confirm supply for next 250 years
- Accurate and complete estimates of national coal reserves are essential for coherent national energy strategies
  - particularly important for community, workforce, and infrastructure planning
Coal Reserve and Quality Assessments

Recommendation:

A coordinated initiative is required to provide a comprehensive accounting of national coal reserves within 10 years

- USGS lead agency
- Coordinate with DOE-EIA, states, and industry
- Estimated additional annual funding of $10 million
Mines of the Future

• The mines of the future will be more challenging:
  - deeper underground mines, potentially higher gas content
  - more complicated surface mines, or may need to go underground
  - aging workforce / new workers
  - working over or under already mined seams

• Implications for mine worker health and safety, environmental protection and reclamation, and mine productivity
Improved Mine Worker Health and Safety

Recommendation:

Expanded health & safety research is needed to reduce exposure of mine workers to hazardous conditions and to improve training of workforce

- NIOSH lead agency
- Coordinate with MSHA and industry
- Estimated additional annual funding of $35 million
Improved Environmental Protection and Reclamation

Recommendation:

Additional research is needed to mitigate adverse environmental impacts associated with past, existing, and future coal mining and processing

- OSM lead agency
- Coordination with EPA and states
- Estimated additional annual funding of $60 million
Improved Mine Productivity and Resource Optimization

Recommendation:

Renew support for advanced coal mining and processing R&D to optimize use of nation’s coal resources

- DOE-Fossil Energy lead agency
- Coordination with NSF, OSM, NIOSH, academic institutions, and coal industry
- **Total estimated annual funding $60 million**
  - $30 million/year total federal support
  - $30 million/year non-federal cost sharing
Coal Transportation

• Rail transportation depends on supply and demand, prevailing business practices, the investment climate, and regulatory oversight, rather than R&D

• Waterborne transportation depends on construction and maintenance of lock-and-dam infrastructure and port facilities

• There is a need to better understand the factors that control complex transportation and transmission networks to minimize the risks of cascading system disruptions
Research to Support Coal Use

- CO₂ emissions pose greatest potential constraint to future coal use
- Need large-scale demonstrations of CCS if coal is to continue its major role in a carbon-constrained world
- Corollary is the need to characterize geologic formations for CO₂ sequestration
- Geologic sequestration sites are ‘resources’
Research to Support Coal Use

Need to supplement existing federal carbon sequestration research

Recommendation:

USGS should play a lead role in identifying, characterizing, and cataloguing the nation’s potential geologic CO$_2$ sequestration resources

- USGS lead agency
- Coordinate with:
  - DOE Carbon Sequestration Program
  - States involved in Carbon Sequestration Program
- Estimated funding for this additional program ~$10 million/year for 5 years
Coal will continue to provide a major portion of energy requirements in the United States for at least the next several decades, and it is imperative that policy makers are provided with accurate information describing the amount, location, and quality of the coal resources and reserves that will be available to fulfill these energy needs. It is also important that we extract our coal resource efficiently, safely, and in an environmentally responsible manner.

A renewed focus on federal support for coal-related research, coordinated across agencies and with the active participation of the states and industrial sector, is a critical element for each of these requirements.
R&D Coordination

- Committee does not recommend a single integrated multi-agency program for coal-related R&D
- Instead, improved interagency coordination and cooperation for each specific R&D area
- Recommends non-federal involvement - states, industry, and academic institutions
- Periodic external peer review an important component of coordination and cooperation
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<tr>
<th>R&amp;D FUNDING SUMMARY</th>
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Thank You!!