Carbon Capture and Storage: Issues and Policies in Appalachia

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Faced with the strong prospect of a carbon constrained future, coal producing companies and states are seeking alternatives which will allow coal to continue as a major source of electric power for the United States. One of the most promising alternatives is Carbon Capture and Storage (CCS).[1]Two researchers found, "Even in a carbon-constrained world, coal mining and coal power can stay in business, thanks to carbon capture and storage."[2]This process consists, "…of separation of CO_2 from industrial and energy related sources, transport to a storage location and long-term isolation from the atmosphere."[3] This paper addresses the legal, technical and economic feasibility issues related to CCS and how these issues are being approached in the nation's second largest coal producing state, West Virginia, and other coal producing states of the Appalachian region.

In addition to West Virginia 25 other states produce coal, but 75 percent of the nation's supply comes from five states WY, WV, KY, PA, and MT.[4] Three of these are in Appalachia. Of the 13 states in the Appalachian Regional Commission (ARC) only four are not coal producers.[5] Coal producing states are or will be considering issues related to CCS.

This is a question of upmost importance to West Virginia. A two university study[6] found the coal economy in 2008 considering both direct and indirect impacts created 63,000 jobs, business volume of $25.1 billion, $7.6 billion of value added, and employee compensation of $3.6 billion. Further $721. 6 million in state and local taxes were generated by firms in the coal economy.

A 2001 University of Kentucky study using 1997 data found total earnings of $6.2 billion and employment of 135,000 in the 118 Appalachian coal producing counties. In central Appalachia the coal mining industry accounts for 29.9 percent of employment and 27.6 percent of earnings.[7]

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[1] Ansolabehere, Stephen et al., *The Future of Coal: An Interdisciplinary MIT Study* (Cambridge: MIT, 2007), 43.
[2] Socolow, Robert H.,and Stephen W. Pacala. "*A Plan to Keep Carbon in Check.*" *Scientific American,* September 2006, 53.
[3]Metz Bert, et al., Working Group III of the Intergovernmental Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage* (Cambridge, UK and New York, NY: Cambridge UP, 2005).
[4] U.S. Energy Information Administration. *Annual Coal Report 2008* (DOE/EIA-0584 (2008)). (Washington, DC: Government Printing Office, 2009)
[5] New York, North Carolina, South Carolina and Georgia are the states with no recorded coal production. (http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/usaimagemap.html)
[6] Witt, Tom and Kent, Calvin. *The West Virginia Coal Economy 2008 (*Morgantown and Huntington WV: Bureau of Business and Economic Research, West Virginia University and Center for Business and Economic Research, Marshall University, 2010)
[7] Thompson, Eric et al., *A Study on the Current Economic Impacts of the Appalachian Coal Industry and its Future in the Region* (Frankfort, KY: Center for Business and Economic Research, University of Kentucky, 2001).

An additional benefit to West Virginia from using coal to generate electricity is the low electricity prices that result from having 98 percent of the State's electricity generated from that source. The same is true in Kentucky. As Table I indicates, West Virginia and Kentucky electric rates are the lowest in the region, significantly below adjoining states, and well below the national average. This provides a positive incentive for economic expansion. A report prepared in Kentucky indicated, "Kentucky's price for electricity remains one of our key competitive advantages."[8] Low electric rates are likely a strong contributing factor to the large manufacturing sector that Kentucky's economy retains relative to the national average.

Not to be overlooked is the impact on the states receiving electricity from West Virginia sources. Around two-thirds of the electricity generated in West Virginia flows to other states[9] which will see their electric bills increase if CCS is implemented. Many of these states are in the Middle Atlantic region which is already experiencing the highest electric costs in the nation.[10]

Table I. Average Retail Price of Electricity to Ultimate End-Use Sector, by State, December 2009 (Cents per Kilowatthour)[11]

State	Residential	Commercial	Industrial
Alabama	9.69	9.80	6.56
Georgia	9.04	8.87	6.18
Kentucky	7.95	7.19	4.63
Maryland	14.31	11.14	9.67
Mississippi	9.44	9.30	6.08
New York	17.75	15.36	9.02
North Carolina	9.44	7.79	5.82
Ohio	10.26	9.23	6.18
Pennsylvania	11.29	9.40	6.96
South Carolina	9.56	8.45	5.53
Tennessee	8.59	8.98	6.05
Virginia	10.12	7.88	6.81
West Virginia	8.01	6.96	5.32
United States	10.93	9.73	6.52

There are significant legal, technical, and economic issues which must be resolved if CCS is to be implemented at a cost which will make coal competitive with other fuels, including renewables. Recognizing this reality legislation was enacted by the West Virginia Legislature in 2009[12] noting the criticality of CCS to the state's economy and establishing a Carbon Dioxide

[8] Smith, Sara et al. *Report of the Kentucky Working Group on Issues of Carbon Sequestration* (Lexington, KY: Smith Management Group, 2010), 6. [Available online at http://www.smithmanage.com]
[9] Data supplied by the West Virginia Department of Commerce, Division of Energy
[10] U.S. Department of Energy, Energy Information Administration. *Electric Power Annual 2008* (DOE/EIA-0348(2008)). (Washington DC: Government Printing Office, 2010)
[11] Data from http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html
[12] HB 2860, Passed April 9, 2009, Code of West Virginia §22-11A Sections 1-9

Sequestration Working Group (CCS Group) to study the scientific, technical, legal and regulatory issues pertaining to CCS.[13] Preliminary reports are due this June with final reports in the summer of 2011.

Legal Issues

The United States does not currently have a federal law which is comprehensive or designed for CCS.[14] There are laws, such as the EPA regulation of underground injection of CO_2 under the Safe Drinking Water Act (SDWA), which pertain to aspects of CCS. Other federal legislations which also apply are the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environment Response Compensation and Liability Act (CERCLA).

A bill introduced into the U.S. Senate[15] in 2009 would have established in the U.S. Department of Energy (DOE): a program for compensating for damages from the geologic sequestration of CO_2, a program to certify storage site closures, a trust fund to pay for the costs associated with federal compensation, and limited the civil claims against owners, operators, generators and pipeline owners. That legislation did not make it out of the Senate Committee on Energy and Natural Resources.

A report completed for Kentucky noted four major legal questions which need answered if CCS is to experience widespread adoption.[16] They are:

- Who owns the "pore" space
- What liability issues arise from the transportation of CO_2
- What should be the liability (short, mid and long term) associated with CCS storage
- What agency should be responsible for regulation of CCS

<u>Ownership of "Pore Space"</u>

Pore space is defined as the "Space between rock or sediment grains that can contain fluids."[17] When injected into deep formations (2,500 feet or below) CO_2 compresses, becomes "supercritical" and turns into a liquid. While there are several possible pore spaces into which CO_2 could be injected, the primary ones of concern to Appalachia involve injection of CO_2 into deep formations of sedimentary rocks including: depleted oil and gas reservoirs, deep unmineable coal seams and deep unused saline water-saturated reservoir rock.[18]

While there is significant precedent established regarding pore space ownership in the underground injection of natural gas for temporary storage and the use of CO_2 injection for

[13] "Carbon dioxide sequestration working group." *Code of West Virginia* §22-11A-6
[14] Hart, Craig A. *Advancing Carbon Sequestration Research in an Uncertain Legal and Regulatory Environment: A Study of Phase II of the DOE Regional Carbon Sequestration Partnerships Program*. Discussion Paper 2009-01. (Cambridge: Belfer Center for Science and International Affairs, 2009), 8.
[15] U.S. Congress. Senate. Senate Bill S.1502, *The Carbon Storage Stewardship Trust Fund Act of 2009*, 111th Cong., 1st Session. Washington, D.C.: Govtrack, 2009. http://www.govtrack.us/congress/billtext.xpd?bill=s111-1502.
[16] (Smith 2010)
[17] (Metz 2005, 410)
[18] (Metz 2005, 199)

enhanced oil recovery (EOR), only recently has the issue in the context of carbon sequestration received legislative attention.[19] It is common practice for mineral and surface interests be severed. If the surface owner has not severed the mineral interests then no ownership issue exists. But if the severed mineral rights have been granted to parties other than the surface owner, legal issues arise. The first issue is whether there has been a severance of the interests and what was covered by the severance. The second issue concerns ownership of pore space after the mineral covered by the severance has been extracted.

Regarding ownership of pore space some states follow the "English Rule" which states the owner of the mineral rights owns the pore space even after the mineral has been exhausted. But most states use the "American Rule" where the surface owner has the rights to the pore space unless it has been specifically granted in the severance. Ownership returns to the surface owner when there is exhaustion of the mineral.[20]

The first state to deal explicitly with CO_2 injection in pore space was Wyoming in 2008[21] which followed the American Rule. The legislation states that ownership of all pore space belongs to the surface owner unless the conveyance of that space has been specifically granted. Judicial decisions over 60 years ago established the same rule in two Appalachian states, West Virginia[22] and Kentucky[23] although both cases dealt with natural gas storage. Under the English rule the mineral rights owner continues with the right to extract the mineral and to the injection of CO_2 provided that injection does not restrict or diminish the owner's of other rights ability to extract other subsurface minerals.

Since CO_2 is a liquid when injected and can be injected into saline formations, laws regarding water rights may in some states be more applicable than those covering mineral rights. Fortunately there is no substantive difference in the laws relating to severing and obtaining mineral and water rights.[24] But state regulations of water rights do vary which will create confusion should stored CO_2 migrate across state boundaries.

One legal issue appearing to be "settled law" is: who owns the CO_2 after injection into the pore space? Is it the owner of the pore space or the owner of the CO_2 when it is injected? If one assumes that the precedents regarding natural gas hold, then injected CO_2 remains the property of the one who owned it at injection.[25] But this does relate to a liability question. If the stored CO_2 escapes and creates harm, who bears the liability? Will it always be the responsibility of the owner even if the owner is not at fault due to the escape being for reasons beyond the owner's control?

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[19] de Figueiredo, Mark A. and Adeeb Fadil, "Emerging Property and Liability Issues for Carbon Sequestration," *Bloomberg Sustainable Energy Law Report* (September 2008).
[20] de Figueiredo, Mark A. et al., *Regulating Carbon Dioxide Capture and Storage* (Cambridge: Center for Energy and Environmental Policy Research, MIT, 2007), 6. The authors note that the question of when a mineral had been exhausted but is then reopened has not been settled and is open for debate.
[21] Fish, Jerry R. "Geologic Carbon Sequestration: Property Rights." Paper presented at the 8th annual Conference on Carbon Capture and Sequestration hosted by the DOE/NETL, Pittsburgh, Pennsylvania, May 4-7, 2009.
[22] Tate v. United Fuel Gas Co. 71S.E.2nd 65 (W.Va. 1952)
[23] Central Kentucky Natural Gas v. Smallwood, 252 S.W. 2nd 866 (Ky. 1952).
[24] (de Figueiredo 2007)
[25] (de Figueiredo 2007)

Regulation of CCS Injection

The U.S. Environmental Protection Agency (EPA) has proposed regulations for CO_2 injection wells under their Underground Injection Control (UIC) provisions of the Safe Drinking Water Act.[26] The EPA acknowledges having no jurisdiction regarding property rights issues but does provide for a new class of injection wells specifically for CO_2. These proposed rules include specific requirements for siting, operation, injection, and post-injection control.

A formidable issue concerns the migration of CO_2, after it has been injected, beyond the geographic boundaries of the property right which was obtained. For injection to be effective a large geographic area covering numerous parcels will have to be secured to encompass the plume. This involves obtaining rights from numerous surface owners. Obtaining these rights will involve transaction costs and creates a "holdout" situation. This problem was handled for oil reserves through "unitization" [27] and for natural gas by acquisition of subsurface easements by eminent domain. In all probability Appalachian states will have to adopt or adapt one of these two methods. While unitization is preferred from an economic standpoint it may be difficult to obtain unless sufficient incentives are provided to owners of pore space.

Liability Under CCS

Liability issues arise at many points in CCS. Relating to pore space there are problems with trespass,[28] whether surface or subsurface. In order for injection to be located, processed, transported, stored and monitored certain surface devices will have to be used, installed and maintained.[29] Usually, the grant of a subsurface right includes necessary surface easements to access, maintain and regulate storage.

There is always a possibility of leakage either in the transport of CO_2 or its storage. While experience with existing CO_2 pipelines and natural gas storage indicate that these incidents will be few and not particularly serious,[30] leakage of CO_2 in sufficient quantity could have disastrous

[26] "Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells." *Federal Register* 73:144 (July 25, 2008) p.43492.

[27] Also known as "pooling." Involves either voluntary or state compulsory consolidation of the rights of the participants providing for, "…the exploration and development of an entire geologic structure or area by a single operation so that drilling and production may proceed in the most efficient and economic manner." U.S. Department of the Interior, U.S. Bureau of Land Management, "Montana/Dakotas: Unitization Exploratory and Secondary" (May 20, 2009) http://www.blm.gov/mt/st/en/prog/energy/oil_and_gas/reservoir_management/unitization.html

[28] Trespass is the use of one's property by another without permission. Goldstein, Paul and Thompson, Jr., Barton *Property Law: Ownership, Use, and Conservation* (New York: Foundation Press, 2006), 53.

[29] U.S. Department of Energy, Office of Science, Office of Fossil Energy. *Carbon Sequestration: State of the Science,* (Washington, DC: Government Printing Office, 1999), 5.1-5.20.

[30] Herzog, Howard. "The Future of Coal: Addressing Carbon and Other Environmental Concerns" Presented at the 2006 EIA Energy Outlook and Modeling Conference, Washington, DC, March 27, 2006. Reported, "… the fraction [of CO_2] retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years, and it is likely to exceed 99% over 1,000 years".
See also Forbes, Sarah M. et al. *CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage*. (Washington, DC: World Resources Institute, 2008), 47.

effects on both the environment and human health.[31] Consensus indicates that pipeline leakages should be regulated with the pipeline owner responsible as is now the case for natural gas.[32]

For short term storage the owner of the CO_2 should be the responsible party. But when the storage facility is closed, and has been for 20 to 30 years, the legal responsibility might pass to a public entity such as a public utility.[33] That entity would finance itself by fees collected on injected CO_2 or by government appropriation. These monies would be placed in a trust fund to cover future liabilities.[34]

Transportation of CCS

Transportation of carbon from the point of capture to the storage area creates legal issues whenever the storage is to occur away from the facility generating CO_2. While there will be significant opportunities for on-site storage of CO_2, as is the case with the pilot projects now undertaken, in many cases facilities capturing CO_2 are likely to be networked with each other using large scale storage sites.[35] There are already over 3.5 thousand miles of CO_2 pipelines in use for EOR[36] with most being in the western states.

Regulation of CO_2 pipelines has precedent in both oil and gas where those pipelines have historically been subject to regulation concerning both access and prices. The regulatory regimes for oil and gas pipelines developed differently. Oil pipelines are considered common carriers while natural gas pipelines are considered public utilities.[37] CO_2 will be transported as a liquid, but it is most likely that regulation will follow that used for natural gas pipelines particularly since the technology is considered to be mature.

Interstate CO_2 pipelines would be regulated by the U.S. Surface Transportation Board (STB) and not the Federal Energy Regulatory Commission (FERC) which has declined to regulate CO_2 transmission.[38] These pipelines would be considered common carriers and required to charge reasonable rates, provide service for all reasonable requests, and insure non-discrimination among shippers. But rates would only be reviewed by the STB if challenged by a shipper. The STB lacks eminent domain authority which would make siting of pipelines subject to state law and obtaining the necessary easements from all landowners.

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[31] Parfomak, Paul, *Carbon Dioxide (CO_2) Pipelines for Carbon Sequestration: Emerging Policy Issues* (Washington, D.C.: Congressional Research Service, 2007), 15.
[32] (Smith 2010, 34)
[33] Anderson, A. Scott et al. The Interstate Oil and Gas Compact Commission, Task Force on Carbon Capture and Geologic Storage, *Storage of Carbon Dioxide in Geologic Structures: A Legal and Regulatory Guide for States and Provinces*, (September 25, 2007), 10.
McCoy, Sean et al. *CCS Reg Project, Policy Brief: Learning and Adaptation in Regulation of Geologic Sequestration* (Pittsburgh: Carnegie Mellon, August 28, 2009).
[34] (de Figueiredo 2007, 11)
[35] (Metz 2005) and (de Figueiredo 2007)
[36] U.S. Dept. of Transportation, *National Pipeline Mapping System*. 2009. https://www.npms.phmsa.dot.gov (accessed March 16, 2010).
[37] (Parfomak 2007)
[38] "General Pipeline Jurisdiction," Title 49 *U.S. Code*, Pts. 15301.

These issues plus the fragmented state permitting processes and overlapping jurisdictional issues make the required large scale siting without bringing CO_2 pipelines under FERC or other federal agency nearly impossible.[39] The experience with oil and gas pipelines supports the federal assumption of pipeline regulation. The necessary interstate networks did not develop until federal control was instigated.

A further issue concerns the classification of CO_2 either as a commodity or as a pollutant.[40] When CO_2 is used for EOR it has a commercial value and states with EOR consider it a commodity. There is great potential for the use of CO_2 in enhanced recovery of coal bed methane (ECBM), but most CO_2 will be considered as an industrial pollution which, under the Supreme Court's decision, would subject it to EPA regulation.[41] Federal legislation establishing CO_2 as a commodity would alleviate the possible conflict between the federal government and the states.

Economic Issues

The overriding issue is can coal continue to compete with other sources of energy after CCS is implemented? CCS will significantly increase the price of using coal. Alternative fuels, including renewables, which are not cost competitive now, may become so with CCS implemented.

A report from MIT analyzed current cost estimates for using CCS in electrical generation.[42] Using today's capture technology, 1.5-2 cents per kWh would be added to the cost of electricity for an Integrated Coal Gasification Combined Cycle (IGCC) or Natural Gas Combined Cycle (NGCC) power plant. For a pulverized coal plant (PC) the increased costs would exceed 3 cents per kWh. MIT found these estimates to be consistent with those from other studies they reviewed.

These costs only referred to carbon capture and did not include transport or storage. The costs were based on a capture efficiency of 90 percent. Included in these costs was the energy penalty, or the amount of electricity which would have to be used to separate the CO_2 at the generation site. Those costs are estimated at: 16 percent for IGCC, 14 percent for NGCC and 28 percent for PC.

The MIT report did indicate that gains in heat rates and reductions in the amount of energy used to separate CO_2 provided the best opportunities to reduce these costs. The new technologies, which are currently being tested, indicate that incremental costs of using CCS at IGCC plants could fall to less than 1 cent per kWh. If these technologies perform as predicted the competitiveness of coal will be enhanced.

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[39] National Commission on Energy Policy. *Siting Critical Energy Infrastructure: An Overview of Needs and Challenges* (Washington, D.C.: Lake Litho Printing & Marketing Services, 2006).
[40] (Parfomak 2007) and (Anderson 2007)
[41] Massachusetts v. EPA. *US Supreme Court.* April 2, 2007. Opinion Available at [http://www.law.cornell.edu/supct/html/05-1120.ZO.html]
[42] David, Jeremy and Herzog, Howard, "The Cost of Carbon Capture." Presented at the 5th International Conference on Greenhouse Gas Control Technologies, Cairns, Australia, August 13-16, 2000.

The U.S. DOE, based on work done for them by SFA Pacific, indicated that the increased average costs of electricity would be 2.5-4 cents per kWh.[43] Studies completed at the DOE's National Energy Technology Laboratory (NETL)[44] found increased costs of 30 percent for using Selexol as a separation agent in a new IGCC plant. Their study also found increased costs of 68 percent in a PC plant which utilized amine scrubbing. A report issued by the EPA[45] saw the total levelized COE for IGCC, supercritical PC and ultra supercritical PC plants with CCS to be 6.58 cents per kWh, 8.56 cents per kWh and 8.24 cents per kWh respectively.

A further NETL study[46] found using today's technologies in new power plants would result in levelized cost of electricity (COE) including the cost of transport, storage and monitoring of 9.7 cents per KWh for NGCC, 10.6 cents per kWh for IGCC and 11.7 cents per kWh for PC. Included were the costs of transport for 50 miles, storage and monitoring for 30 years as only 0.4 cents per kWh. The report also investigated initial capital costs finding that NGCC had the lowest capital costs of $1,172 per kW but this would double with CCS. The capital costs per kWh for PC was $2,883 and for IGCC $2,496.

All of the above cost estimates are summarized in Table II.

Table II. Estimated Costs for Carbon Capture and Sequestration (per kWh)

	IGCC	NGCC	PC	Cost of Transport	Cost of Storage
MIT	1.5-2¢	1.5-2¢	>3¢	NA	NA
MIT[47]	0.66¢	0.38¢	1.16¢	$10/ton CO_2 (additional)	NA
MIT	1-3¢	1-2¢	2-4¢	$0.50/metric ton/100 km by pipeline (additional) $6/metric ton/100km by truck (additional)	$2-15/ton of CO_2
DOE	2.5-4¢	2.5-4¢	2.5-4¢	NA	NA
NETL	2.4¢		3.25¢	NA	NA
NETL	10.6¢	9.7¢	11.7¢	Included	Included
EPA	6.58¢		Supercritical: 8.56¢ Ultra Supercritical: 8.24¢	NA	NA

[43] Plasynski, Sean, *Carbon Capture Research*, September 6, 2007. Office of Fossil Energy, U.S. Department of Energy. http://www.fossil.energy.gov/programs/sequestration/capture. html (accessed November 3, 2009).
[44]The Energy Lab. *Carbon Sequestration FAQ Information Portal*. NETL. http://www.netl.doe.gov/technologies/carbon_seq/FAQs/tech-status.html (accessed March 4, 2010).
[45] Nexant, Inc., subcontractor of The Cadmus Group, Inc. *Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies.* Prepared for U.S. EPA. (EPA-430/R-06/006, 2006). (Washington DC: Government Printing Office, 2006), Sec. 5, p. 11.
[46] Woods, Mark C. et al., *Cost and Performance Baseline for Fossil Energy Plants: Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report, Revision 1, August 2007*. Prepared for NETL. (DOE/NETL-2007/1281), (Washington DC: Government Printing Office, 2007), 9.
[47] Estimates for decrease in incremental costs with increase in technology

The NETL data presented to the WV Study Group indicates that coal, even with CCS, can be competitive for new plants including transport and storage. This data is presented in Table III. For new builds CCS is competitive with other fuels including renewables but is not as low cost as biomass.

Table III. Levelized Costs by Plant Type for Plants Entering Services in 2016 (2008$/MWh)[48]

Plant Type	Levelized Cost of Electricity ($/MWh)	Rank
Biomass	$111.0	1
NGCC with CCS	$113.3	2
Advanced Nuclear	$119.0	3
Advanced Coal with CCS	$129.3	4
Wind	$149.3	5
Solar Thermal	$256.6	6

But if existing electric generating plants are to be retrofitted the costs are significantly higher.[49] The increase in the cost of electricity from a retrofit or rebuild ranges from 5.61 cents per kWh to 7.71 cents per kWh depending on the type of plant and the method used. These increases would be added to the current average cost of 2.06-2.21 cents per kWh. These increased costs are from both the capital costs and the reduction in plant efficiency which could be as high as 40 percent. The NETL recently estimated the cost of electricity for a retrofitted plant with CCS to bet $133.9 per Mwh.[50]

Rebuilding the core of an existing plant has a higher capital cost but the efficiency loss is less. The MIT report concluded: "… that retrofits seem unlikely…that rebuilds including CO_2 capture appear more attractive than retrofits particularly if they upgrade low-efficiency PC units with high-efficiency technology."[51] But in both instances the COE from these plants may render them uncompetitive.

Policy Issues

Research and Development (R&D)

The DOE set forth the overarching policy agenda for CCS. "For carbon sequestration to be a viable option, it needs to be safe, predictable, reliable, measurable and verifiable; and it needs to

[48] Data from Energy Information Administration. *Annual Energy Outlook 2010*. DOE/EIA-0383(2009). Available online at http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html (Accessed April 5, 2010).
[49] (Ansolabehere 2007, 145-148)
[50] Ciferno, Jared. US Department of Energy and National Energy Technology Laboratory. *CO_2 Capture-Ready Coal Power Plants*. DOE/NETL-2007/1301. (Washington, DC: Government Printing Office, 2008).
[51] (Ansolabehere 2007, 29)

be competitive with other carbon management options, such as energy-efficient systems and decarbonized energy technologies."[52] The DOE report advocated a significantly expanded R&D program for all aspects of CCS to be financed primarily by the federal government considering the "high-risk" nature of the inquiries. Federal support for CCS has expanded since that report. As part of the stimulus package over $2.5 billion was made available for CCS projects.[53] The Clean Air Task Force sees potential high returns from advancing research of CCS including the investigation of underground carbon gasification (UCG).[54] The World Resources Institute also has proposed an ambitious research agenda which could result in lower costs, greater safety and fewer emissions. The Clean Air Task Force echoed the recommendation.

Property Rights

The issue calling for the most immediate action is for all states to define property rights in pore space. As noted above only a few states have clearly established ownership of pore space for carbon injection and storage.[55] When state statutes regarding severed interests in oil and gas were established no consideration was given to CO_2. Legislation concerning oil and gas rights in severed interests may not be appropriate or courts may decide that CO_2 is not covered at all creating a legal vacuum.

Regarding issues concerning obtaining and using pore space, another Carnegie Mellon report[56] was concerned with the possible competition of CCS with other subsurface uses that occur at similar depths. These included groundwater recovery, hydrocarbon production, natural gas storage, fluid waste disposal and compressed air storage. Noting that the EPA has no authority over subspace usage and there is limited to no state or other federal authority, the report calls for EPA regulation under the UIC. This delegation would allow the EPA to permit projects and allocate pore spaces. Where a state has been able to obtain primacy for UIC regulation, the state would continue with that authority. Since many geologic basins underlie more than one state, a regional coordination mechanism would have to be established.

The World Resources Institute made extensive investigation of storage concerns.[57] Finding there is not "full clarity" on the issue of sub-surface ownership rights, they encouraged all states to deal with clarification. WRI discusses an alternative to the "private ownership" model (where the owner has all the property rights): a "public interest" model where the government could exercise power over property rights as in the case of air space where flight patterns are established by the FAA for reasons of public safety. State authorities should have the legal authority to define ownership of pore space and to require "compulsory joining of all

[52] Office of Science. U.S. Department of Energy. *Carbon Sequestration Research and Development*. (Washington, DC: Government Printing Office, 1999), xix. Also available online at http://www.fossil.energy.gov/programs/sequestration/publications/1999_rdreport/front_feb.pdf
[53] (Smith 2010, 8)
[54] Clean Air Task Force. *Coal Without Carbon: An Investment Plan for Federal Action.*(Boston, MA: 2009).
[55] (de Figueiredo and Fadil 2008, 2-3)
[56] Department of Engineering and Public Policy, Carnegie Mellon University. *CCSReg Project: Policy Brief: Governing Access To and Use of Pore Space for Deep Geologic Sequestration*. (Pittsburgh: Carnegie Mellon University, 2009)
[57] (Forbes 2008, 53-104)

participating interests in the reservoir" as in the IOGCC suggested rules.[58] In the European Union the national governments owns the core space.[59]

States control their own property law and state courts interpret those laws. The issue may revolve around the definition of the mineral rights severed. If CO_2 is considered to be a mineral or ownership of it considered to have been granted under a general severed mineral right then the courts may find the owner of the oil or gas rights to own the pore space.[60] On the other hand, the courts may find that a general severed mineral interest lacks the specificity to determine ownership. Considering the probability of interstate flows of CO_2 plumes, consistent state laws on severed property rights specifically dealing with CO_2 and related legal issues should be a priority.

Storage

The two states having gone the furthest in dealing with CCS issues are Wyoming and North Dakota. Both of these follow closely the recommended protocols of the IOGCC[61] and The World Resources Institute.[62] While agreeing on most issues the IOGCC guidelines begin, "…given the jurisdiction, experience and expertise of states…in the regulation of oil and natural gas production and natural gas storage…(the states) would be the most logical and experienced regulators of the geologic storage of carbon dioxide."[63] The WRI appears to see a more active federal role particularly on transportation and environmental issues. Both have detailed recommendations covering all aspects of this issue which are not reviewed in this paper.

The DOE created the Regional Carbon Sequestration Partnerships Program to, "develop the infrastructure and knowledge base needed to commercialize carbon sequestration technologies."[64] The most common legal issue encountered by those in the partnerships was long-term liability for storage. Specific liabilities concerned health and safety risks, property damage to land, water supply, minerals, the leakage of CO_2, and potential tort liability for trespass of CO_2 plumes into other property.[65] Based on that concern the Partnership participants determined the most pressing issue for government was to consider long term liability associated with storage.[66]

The Interstate Oil and Gas Compact Commission (IOGCC)[67] after an extensive review of the law recommended state statutes and rules clearly identify the surface owner as the holder of rights to store in leased pore space unless there was a provision in the lease to the contrary. But this right would be limited to not allowing injection and storage in formations containing commercially viable oil, gas, coal or other mineral deposits. The IOGCC task force reported the best way to

[58] (Anderson 2007, 26)
[59] (Forbes 2008, 83)
[60] (Smith 2010, 22)
[61] (Anderson 2007)
[62] (Forbes 2008)
[63] (Anderson 2007, 1)
[64] (Hart 2009, 9)
[65] (Hart 2009, 12)
[66] (Hart 2009, 21)
[67] (Anderson 2007, 3)

deal with long-term monitoring and liability issues is by establishing a two stage closure and post-closure period. Through the first period the operator would hold the liability. After completion of this period liability would transfer to the state.[68].

A report completed by Carnegie Mellon calls for a new entity, the Federal Geologic Sequestration Board, to be established to handle long-term storage stewardship issues.[69] All sources call for funding to come at least in large part from those involved in CCS.

Transportation

Recommendations regarding pipelines have been advanced by several groups. The Midwest Governors Association advocated a more effective method of installing transportation routes along with extended eminent domain authority to facilitate pipeline construction.[70] They called for continued state regulation.

The WRI has a different view, "As CO_2 pipelines are developed at the scale required for CCS legislation imposing federal siting and economic regulation...could be warranted…the jurisdiction of these pipelines could fall under the purview of the Federal Energy Regulatory Commission."[71] Using FERC instead of state regulation deals with several problems as FERC has the power of eminent domain for those interstate pipelines which are common carriers and have a certificate of public convenience and necessity. For intrastate transport states should follow the example of those states which have granted eminent domain power to common carriers and public utilities.[72]

A similar tact was taken in a report by Carnegie Mellon University.[73] Under their proposal pipeline operators would have an "op-in" available where they would be able to enter under FERC regulation. If they chose they could remain under the current regime on state siting and economic regulation. This option would exist only for new pipelines and would not be available for existing ones. They also recommended that the permitting process for sites on federal land be streamlined and the existing pipeline safety regulatory framework should continue to be utilized.

State Legislation in Appalachia

Pennsylvania has legislation introduced which declared deep core space to be owned by the state.[74] The legislation also would establish a "carbon dioxide sequestration network" on state

[68] (Anderson 2007, 11)
[69] Department of Engineering and Public Policy. *CCS Reg Project: Policy Brief Summaries,* (Pittsburgh, PA: Carnegie Mellon University, 2009), 2.
[70] Johnson, Jennifer. Prepared for the Midwest Governors Association. *Energy Security and Climate Stewardship Platform for the Midwest: Toolkit for Carbon Capture and Storage: Statutory and Regulatory Issues* (Midwest Governors Association, 2009), 4.
[71] (Forbes 2008, 49)
[72] Ibid.
[73] Department of Engineering and Public Policy, *CCS Reg Project: Policy Brief: Regulating Carbon Dioxide Pipelines for the Purpose of Transporting Carbon Dioxide to Geological Sequestration Sites,* (Pittsburg: Carnegie Mellon University, 2009).
[74] PA HB 80, Amending the Alternative Energy Portfolio Standards Act

owned land and gives the Department of Conservation and Natural Resources regulatory authority over CCS storage. The Public Utilities Commission would control pipeline transportation. A state Carbon Dioxide Indemnification Fund would be created funded by fees and fines collected from those injecting and owning CO_2.

In Kentucky there have been three pieces of legislation introduced but to date none have passed. One would give the state all rights, title and interest in sequestered carbon plus any economic benefits including carbon credits which might result from the sequestration.[75] Another bill would have the state development authority give financial incentives for the building of a pilot CCS project.[76] The last bill would create a legal study group to deal with impediments to "CCS in the state.[77]

The issue of pore space ownership was settled in West Virginia with the passage of HB 2860 in 2009 which vested pore space ownership with the surface owner unless specifically provided in the deed severing the subsurface interests. The West Virginia Department of Environmental Protection was granted the authority to issue permits for carbon sequestration. A CCS Task Force was established to make recommendations to the legislature regarding legal, technical, scientific, and economic feasibility issues of CCS in 2012.

Pilot CCS Projects in Appalachia

In 2009 American Electric Power began the capture of CO_2 at its Mountaineer Plant in New Haven, West Virginia.[78] This is the first effort to combine into a single project the capture of CO_2 from the flue gas of a coal powered electric plant and storage of the CO_2 on site. The project will capture and store around 90 percent of the carbon emissions from a 20 megawatt plant. It will store approximately 100,000 metric tons of CO_2 annually at a depth of 1.5 miles.

Under a grant from the DOE the Midwest Regional Carbon Sequestration Partnership successfully injected 1,000 metric tons of CO_2 into Mt. Simon Sandstone at Duke Energy's East Bend Generating Station in Boone County KY. The Western Kentucky Carbon Storage Foundation in 2009 drilled a test-well in Hancock County KY and injected 323 tons of CO_2 into a 8,126 foot well.[79]

Conclusions

As the WRI report notes coal will be needed as a fuel into the future, "CCS is considered an essential element in a portfolio of approaches for reducing carbon emissions because it appears to be deployable and there is an enormous amount of potential storage capacity located around the world. To make significant reduction in greenhouse gas (GHG) emission by mid-century,

[75] KY HB 351, Carbon Capture and Sequestration
[76] KY HB 285, 2009 Regular Session
[77] KY HB 537, 2009 Regular Session
[78] Carbon Capture & Storage. America Electric Power. http://www.aep.com/environmental/climatechange/carboncapture/default.aspx (accessed March 4, 1010).
[79] (Smith 2010, 13)

large-scale reduction opportunities, including CCS will most likely be needed."[80] That finding that was confirmed by the IPCC.[81]

Considering the current emphasis on reducing the nation's carbon footprint, CCS is one of the alternatives to be considered along with energy efficiency and use of renewable energy sources. CCS should not be viewed as an alternative for increased efforts toward energy efficiency or expanded development of alternate and renewable sources of energy. The U.S. Energy Information Administration (EIA) projections over the next few decades[82] indicate that in addition to increased energy efficiency the U.S. will need all the fuels, including renewables, alternatives and coal, that are or will become available. CCS should be viewed as competing with either increased energy efficiency or the use of renewable and alternative fuels.

In light of the abundant coal resources in Appalachia, the importance of the coal industry to many of the Appalachian states and the existence of enormous amounts of potential pore space in the region, the states should be moving quickly and significantly to enact the policies which will enhance CCS adoption and development. To date that effort is just in its infancy.

Among the alternatives which Appalachian states should consider is the inclusion of electricity generated from facilities using CCS as part of their energy portfolios. Under these portfolios a percentage of the electricity used in the state must come from alternative and renewable sources. While these state portfolios vary in terms of definition of "alternate and renewable energy", the percentage which is to come from each source, the overall percentage and the dates by which the percentage is to be met,[83] there is room for including CCS in the portfolios. This would create incentive for the development of CCS facilities and is included in discussions regarding CCS in Pennsylvania.

Because of the variety of ways to capture CO_2 and the need to demonstrate the most effective technologies, the literature reviewed in this report all recommend a "flexible" regulatory approach. Legislation needs to allow for adaptation to the "swiftly changing" developments in CCS technology.[84] The geographic interrelationships of CCS call for a higher level of regional cooperation than has been the case to date.

It is in the best interests of all that emission of GHGs be reduced and coal continues as an economic engine in Appalachia. CCS meets both those objectives.

[80] (Forbes 2008, 20)
[81] (Metz 2005, 19)
[82] U.S. Department of Energy, U.S. Energy Information Administration. *Annual Energy Outlook 2010: Early Release Overview*. DOE/EIA-0383(2010). (December 2009). http://www.eia.doe.gov/oiaf/aeo/overview.html (accessed March 4, 2010).
[83] Center for Business and Economic Research. *Energy Efficiency and Renewable Energy in Appalachia: Policy and Potential.* Prepared for the Appalachian Regional Commission. (Huntington, WV: Marshall University, August 2006).
[84] (Forbes 2008, 8)