Report to the Legislature

Findings and Recommendations with Respect to the Development and Widespread Deployment of Carbon Dioxide Sequestration throughout West Virginia

Submitted by:

The West Virginia Carbon Dioxide Sequestration Working Group

July 1, 2011

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Summary of Terminology, Abbreviations, and Acronyms

ACES	American Clean Energy and Security Act
ALJ	Administrative Law Judge
AoR	Area of Review
ARRA	American Recovery and Reinvestment Act
BACT	Best Available Control Technology
CAA	Clean Air Act
CCS	Carbon Capture and Sequestration
CO_2	Carbon Dioxide
DOE	U.S. Department of Energy
EOR	Enhanced Oil Recovery
GHG	Greenhouse Gas
GS	Geological Sequestration
GW	Gigawatt
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
IOGCC	Interstate Oil & Gas Compact Commission
kWh	Kilowatt Hour
MGA	Midwest Governors Association
MIT	Massachusetts Institute of Technology
MRCSP	Midwest Regional Carbon Sequestration Partnership
MRV	Monitoring, Reporting, and Verification
MVA	Monitoring, Verification, and Accounting

Mt	Million metric tonnes (*i.e.* one billion kilograms)
MWh	Megawatt Hour
NEPA	National Environmental Policy Act
NETL	National Energy Technology Laboratory
NO_x	Nitrogen Oxides
NSPS	New Source Performance Standards
PEA	Public Energy Authority
PISC	Post-Injection Site Care
PSC	Public Service Commission
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation & Recovery Act
SDWA	Safe Drinking Water Act
SO_2	Sulfur Dioxide
TWh	Terawatt Hour
U.S.	United States
UIC	Underground Injection Control
USEPA	United States Environmental Protection Agency
USDW	Underground Source of Drinking Water
WVDEP	West Virginia Department of Environmental Protection
WVGES	West Virginia Geological and Economic Survey

WORKING GROUP MEMBERS

The Act requires the appointment of certain members to the Working Group by the Secretary of the West Virginia Department of Environmental Protection ("WVDEP"), and the state geologist, the Director of the West Virginia Geological and Economic Survey. The following current members were appointed in compliance with the Act in July 2009 by Secretary Randy Huffman and Dr. Michael Hohn:

Experts in carbon dioxide sequestration or related technologies:
Grant Bromhal - National Energy Technology Laboratory
Cal Kent, Ph.D - Marshall University
Ken Nemeth - Southern States Energy Board
Richard Winschel - Consol Energy, Inc.

Expert in environmental science:
Stephanie R. Timmermeyer, Esq. - Timmermeyer PLLC

Expert in geology:
Tim Grant - National Energy Technology Laboratory

Attorneys with expertise in environmental law:
David M. Flannery, Esq. - Jackson Kelly PLLC
Leonard Knee, Esq. - Bowles Rice McDavid Graff and Love, LLP

Expert in engineering:
Paul Kramer - Allegheny Energy, Inc.

Experts in the regulation of public utilities in West Virginia:
Billy Jack Gregg
Earl Melton - WV Public Service Commission

Representative of a citizen's group advocating environmental protection:
Vickie Wolfe - WV Environmental Council

Representative of a coal power electric generating utility advocating carbon dioxide sequestration development:
Tim Mallan - Appalachian Power

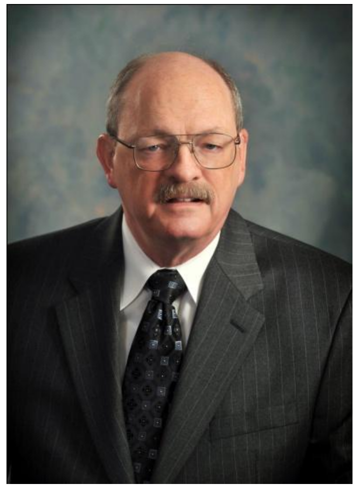
Engineer with an expertise in the underground storage of natural gas:
John Leeson - Dominion Transmission

Chairman of the National Council of Coal Lessors, Inc.:
Nick Carter and Greg Wooten , named as his alternate

Representative of the Coal Association:
Jim Laurita - MEPCO

Representative of West Virginia Land and Mineral Owners Association:
Alan Dennis - Penn Virginia Coal Company

Representative advocating the interests of surface owners of real property:
David B. McMahon, Esq.



TIMOTHY P. MALLAN

JUNE 25, 1947 – DECEMBER 26, 2010

This Report to the Legislature is dedicated to the memory of Timothy P. Mallan, Environmental Affairs Manager, Appalachian Power Company, who served with distinction as a member of the West Virginia Carbon Dioxide Sequestration Working Group and as the Chair of its Feasibility Subcommittee.

I. EXECUTIVE SUMMARY

I.A. BACKGROUND

During the 2009 Regular Session, the West Virginia Legislature passed H.B. 2860 which was added to the West Virginia Code as Carbon Dioxide Sequestration, Article 11A of Chapter 22. The Legislature listed among its findings that "[i]t is in the public interest to advance the implementation of carbon dioxide capture and sequestration technologies into the state's energy portfolio." Recognizing that there are administrative, technical and legal questions involved in developing this new technology, the Code authorized the West Virginia Department of Environmental Protection (WVDEP) Secretary to establish a Carbon Dioxide Sequestration Working Group ("Working Group"). The Working Group is charged with studying all issues related to the sequestration of carbon dioxide and to submit a preliminary report to the Legislature on July 1, 2010, followed up by a final report on July 1, 2011. The final report addresses the following:

- A recommendation of the appropriate methods to encourage the development of carbon dioxide sequestration technologies;
- An assessment of the economic and environmental feasibility of large, long-term carbon dioxide sequestration options;
- A recommendation of any legislation the working group may determine to be necessary or desirable to clarify issues regarding the ownership and other rights and interest in pore space;
- A recommendation of the methods of facilitating the widespread use of carbon dioxide sequestration technology throughout West Virginia;
- Identification of geologic sequestration monitoring sites to assess the short-term and long-term impact of carbon dioxide sequestration;
- An assessment of the feasibility of carbon dioxide sequestration in West Virginia and the characteristics of areas within the state where carbon dioxide can be sequestered;
- An assessment of the costs, benefits, risks and rewards of large-scale carbon dioxide sequestration projects in West Virginia;
- An assessment of the potential carbon dioxide sequestration capacity in this state;
- Identification of areas of research needed to better understand and quantify the processes of carbon dioxide sequestration; and
- An outline of the working group's long-term strategy for the regulation of carbon dioxide sequestration in West Virginia.

(W. Va. Code § 22-11A-6(h)(1)-(10)).

This Final Report was prepared and submitted in compliance with the Carbon Dioxide Sequestration Act. It describes the efforts of the Group to date and makes recommendations and conclusions.

Notably, after the Carbon Dioxide Sequestration Act was passed during the regular session in 2009, a Special Session was held in June 2009. During that session, the Legislature promulgated the Alternative and Renewable Energy Portfolio Standard, Article 2F of Section 24 of the West Virginia Code. This new law states that "[t]o continue lowering the emissions associated with electrical production, and to expand the state's economic base, West Virginia should encourage the development of more efficient, lower-emitting and reasonably priced alternative and renewable energy resources."

"Advanced coal technology" is included in the list of defined "alternative energy resources." W. Va. Code § 24-2F-3(c)(1). Advanced coal technology is defined as "a technology that is used in a new or existing energy generating facility to reduce airborne carbon emissions associated with the combustion or use of coal and includes, but is not limited to, *carbon dioxide capture and sequestration technology*, . . . and any other resource, method, project or technology certified by the commission as advanced coal technology." W.Va. Code § 24-2F-3(a) (emphasis added).

It is clear to the Working Group that passage of the Alternative and Renewable Energy Portfolio Standard almost contemporaneous with passage of the Carbon Dioxide Sequestration Act indicates the Legislature's high levelly of interest in carbon capture and sequestration technology and its desire for West Virginia to be a leader in deployment of such technology if feasible from an environmental, economical, and legal standpoint.

I.B. ORGANIZATION OF THE FINAL REPORT

While the list of ten items the Working Group is charged with considering may be categorized broadly into three areas, many of them overlap. This constituted some challenge with organization for a useful final report. The Group decided to organize this report by way of discussing feasibility issues first, geology and technology issues second and legal issues last. In each of these three broad sections, any conclusions and/or recommendations reached by the Group are clearly stated at the end of the section.

The Final Report provides the Working Group's conclusions and recommendations.

I.C. FEASIBILITY SUBCOMMITTEE

The Working Group believes that it is highly likely that West Virginia will be faced with having to significantly reduce the state's emissions of greenhouse gases in the near future. The state currently emits approximately 102 million metric tons of greenhouse gases each year with about 86 million metric tons of that being emitted from coal-fired power plants. The state is one of the nation's largest exporters of electric power to other states. Power plants were originally built in the state to be near the primary fuel source and West Virginia contains enough generating capacity to meet the state demand and provide extensive power to its neighbors.

The United States Environmental Protection Agency ("USEPA") has designated carbon dioxide and other greenhouse gases as "regulated" pollutants and there is a strong desire on the federal level to reduce greenhouse gas emissions. This reality, coupled with increased international pressure on the US in this area, means emissions in West Virginia may soon have to be reduced. With these issues as a backdrop, the Feasibility Subcommittee concentrated on assessing the magnitude of the reductions West Virginia may be asked to make and whether or not CCS[1] technology can contribute to a potential solution to this challenge.

Factors to assess in this investigation include costs of such technology, impacts on the state's economy, public safety and environmental concerns, and goals of the state that may be impacted by CCS. This subcommittee also proposed some incentives the state may want to consider should it be determined that deployment of CCS is in the state's interest (see section IV.C.6.).

In general, the magnitude of the reductions needed to achieve the goals of any currently proposed emissions reduction targets are so large that multiple approaches are needed because no single technology or life style change can achieve them. Current Congressional proposals call for a reduction in US greenhouse gas emissions of 83% by 2050. Elimination of all coal-fired power in the nation would still leave 70% of the greenhouse gas emissions currently emitted from US sources. CCS may be part of the solution to greenhouse gas emissions, but significantly more will have to be done to achieve these goals.

The economic cost of CCS technology can be estimated, but because the technology is in the early stages of development, such cost projections are subject to modification. Section IV.A.3. gives a comparative costing for various technologies with varying greenhouse gas impacts, but predicting costs at this time is extremely difficult. Technology development, economic recession and national and international affairs may play a huge role in such projections. Section IV.A.3.b. helps outline some of the information that may be needed to assess the overall impact of CCS on the economy of West Virginia, but acknowledges that much of the needed data are not yet available. The Legislature may want to inquire into this question in the near term.

From a public safety and environmental impact point of view, there are some important questions that still need to be resolved. The Mountaineer CCS project in Mason County, West Virginia, is attempting to answer some of these questions. The Legislature will want to carefully consider the observation in section IV.A.4. and continue to insist that appropriate technical consideration be given to designing regulatory structure to assure long term protection of these values.

In the coming year the Feasibility Subcommittee will assess and attempt to resolve some of the following topics:

1. In the face of growing concern over greenhouse gas emissions, should and if so to what extent should West Virginia investigate other methods of generating electrical and other forms of power?
2. Should the Legislature investigate potential regulations and or promotion of intrastate and interstate CO_2 pipelines?
3. What factors need to be considered in the assessment of the value of coal-fired power to West Virginia?

[1] The term "CCS" is used frequently throughout the Final Report. The Working Group agreed that CCS shall be interpreted to refer to Carbon Capture and Sequestration instead of Carbon Capture and Storage. The terms "sequestration" and "storage" are often used interchangeably so the Group agreed to the use of "sequestration" throughout the report. The Legislature defines carbon dioxide capture and sequestration as "the capture and secure storage of carbon dioxide that would otherwise be emitted to, or remain in, the atmosphere." W. Va. Code §22-11A-2(9).

4. The subcommittee will delve deeper into the economic cost and impact on West Virginia of CCS technology.
5. What facts need to be brought to the attention of the West Virginia Legislature to enable that body to make an informed decision about the importance of CCS technology development in the state?

I.D. GEOLOGY & TECHNICAL SUBCOMMITTEE

There is potential for sequestration of captured carbon dioxide in West Virginia. The state is one of eight that overlies the sedimentary section of the Appalachian Basin, one of the major sedimentary basins in the continental United States. Potential carbon dioxide sequestration beneath West Virginia was initially assessed by the Midwest Regional Carbon Sequestration Partnership (MRCSP) in its Phase I report. Several formations in the stratigraphic column have potential for storage in either depleted oil and gas reservoirs or in saline reservoirs. There are also several formations that will provide a seal, providing containment of the sequestered carbon dioxide. Coal, a valued natural resource in West Virginia, also presents some storage potential in unmineable seams. Storage potential in shale formations is also considered by the MRCSP. Organic rich shale and coal have similar trapping mechanisms for sequestration where the carbon dioxide molecule is bound to the organic material. However, shale storage potential is still a research project and is not considered in the 3rd edition of NETL's Atlas.

The MRCSP estimates the potential for geologic sequestration of carbon dioxide in West Virginia at about 60,810 million metric tons.[2] This includes an estimate of storage potential in shale. In its second edition of the Carbon Sequestration Atlas of the United States and Canada, the National Energy Technology Laboratory (NETL) provides a range in geologic storage potential for West Virginia of between 4,873 and 14,994 million metric tons. Storage potential in shale is not included in NETL's atlas; more research work needs to be conducted to better understand trapping mechanisms in shale, providing a better understanding of the storage potential in these formations.

Emission data for West Virginia in the 2nd edition of NETL's Atlas lists 29 sources emitting 102 million metric tons per year (see Table IV.B.10). With 90 percent capture this volume of CO_2 emissions can be injected for sequestration over a period of between 53 years and 163 years. The third edition of the Atlas lists 27 sources emitting 99.2 million tonnes per year. With a slightly wider range in storage efficiencies, potential storage capacity for West Virginia is between 6,630 and 20,260 million tonnes.[3] With 90 percent capture, this could accommodate between 74 and 226 years of injection. The United States Geologic Service will be providing an assessment of onshore storage potential for CO_2 per Congressional direction in the Energy Independence and Security Act of 2007. Storage potential estimates are resource estimates that need to be proven. This will be done to some degree during site characterization of a potential sequestration site. As with other natural resources such as oil and gas or coal, proved reserves are a smaller value than the resource estimate.

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[2] Wickstrom, L.H. et al., 2005, Characterization of Geologic Sequestration Opportunities in the MRCSP Region, Phase I Task Report Period of Performance: October 2003-September 2005, DOE/NETL DE-PS26-05NT42255

[3] NETL, 2010, Carbon Sequestration Atlas of the United States and Canada, third edition. Found at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIII/index.html

The United States Environmental Protection Agency (USEPA) recently published the final rules for Class VI injection wells in December 2010, a new Underground Injection Control (UIC) rule classification required for injection of captured CO_2 into subsurface geologic reservoirs for geologic sequestration (GS). Authority to issue the Class VI rules is derived from the Safe Drinking Water Act (SDWA). At the same time, EPA also recently published final mandatory reporting rules for greenhouse gas (GHG) reporting for CO_2 GS operations, Subpart RR. These GHG reporting rules are based on Clean Air Act (CAA). The Class VI rules are designed to protect U.S. drinking waters (USDWs) and assure that the sequestered CO_2 does not present an endangerment to USDWs. Subpart RR is designed to track CO_2 as it moves through a sequestration operation and provide an accounting of the volume of captured CO_2 sequestered. Several states have passed geologic storage legislation and two, Washington and North Dakota, have promulgated regulations governing sequestration of captured CO_2.

The prime factor to consider in CO_2 storage operations is pressure. Captured carbon dioxide is most economically stored in a supercritical phase. Depending on temperature and pressure gradient, this will occur at a depth of 2,500 feet and deeper. Saline storage provides the most potential for sequestration but the pore space is filled with water. While oil and gas production deplete the pressure of the reservoir, carbon dioxide sequestration will increase reservoir pressure to facilitate storage. Higher pressures and displacement of formation fluids to accommodate storage are the two fundamental concerns addressed by the Class VI injection well rules. Once injection ceases, the storage reservoir pressure will begin to return to pre-injection operation pressures. The USEPA recommends a 50 year post injection monitoring period, although the Administrator may modify this on a case-by-case basis, because it estimates that this is how long it will take the CO_2 storage reservoir pressure to return to regional hydrostatic pressure levels and provide a condition of non-endangerment.[4]

Two recent studies looked at storage costs. The Global CCS Institute estimated storage site characterization cost to be $25 million on average with a range of $10 to $150 million. Its study recommended assembling a list of six to eight prospects from which to select a site for characterization. There is some probability that the first site selected will not meet expectations and will have to be abandoned for another site. Its model assumed a characterization cost of $60 million. The higher cost estimate from the Global CCS Institute's study suggests a 17 percent success rate.[5] Early movers here should have better success since they will be able to select optimal sites. Taking a global perspective, the International Energy Agency (IEA) looked at CCS storage costs with respect to meeting the goal of having 20 large scale CCS projects active by 2020. Its cost estimates ranged from €9 million to €81 million with an average of €30 million. At the current exchange rate of $1.44 per Euro, these costs are $13 million to $117 million with an average of $43 million.[6] The Global CCS Institute model assumed that it will take up to nine years before injection can begin. The IEA model assumes a similar time frame at a minimum. In Table IV.B.2, an estimate of between 3.5 and 6 years is suggested for regional geologic evaluation, site selection and characterization and permitting. If storage costs range

[4] EPA, 2008, Proposed rules for Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells. (web link needed)

[5] Glogbal CCS Institute, 2009, Strategic Analysis of the Global Status of Carbon Capture and Storage, Report 2: Economic Assessment of carbon Capture and Storage Technologies. Found at: http://www.globalccsinstitute.com/sites/default/files/Report%202-Economic%20Assessment%20of%20Carbon%20Capture%20and%20Storage%20Technologies_0.pdf

[6] IEA, 2011, Global Storage Resource Analysis for Policymakers, IEA CCS Costs Workshop, Paris, March 22-23, 2011. Found at: http://www.ieaghg.org/docs/General_Docs/IEAGHG_Presentations/Gap_Analysis_IEA_CCS_NW_Mar11_v2.pdf

from \$5.00 to \$10.00 per tonne then sequestering 100 million tonnes of CO_2 can cost between \$500 and \$1,000 million dollars. With site characterization a cost including permitting of \$60 million, then it is easy to see that the majority of expenses incurred by sequestration occur after injection begins, driven by MVA activity, tracking the CO_2 plume and assuring non-endangerment at some point in time after injection is done.

Successful site characterization begins with regional geologic evaluation over a broad geographic area. The quality of geologic data that can be assembled is critical to making a multi-million dollar investment in site characterization. Class VI permit application requires the preparation of several plans: Area of Review (AoR) and corrective action, testing and monitoring, injection well plugging, post-injection site care (PISC) and site closure and emergency and remedial response. Establishing financial responsibility that covers fulfillment of several of these plans: corrective action, injection well plugging, post-injection site care (PISC) and site closure and emergency and remedial response, is also required to gain a permit.

Site characterization takes only a few years. MVA during operations will be over decades. Class VI rules require a review of the Area of Review plan every at least every five years. This effort will involve seismic data acquisition of some sort, 2-D, 3-D, vertical seismic profile (VSP) or cross-well seismic. This will represent the greatest expense in meeting regulatory requirements. An annual mechanical integrity test of injection wells is also required. Periodic sampling and testing of the storage reservoir, formations above the seal and groundwater will be conducted through monitoring wells. Corrective action, and remediation of old wellbores, will be done as the plume expands.

Sequestration operations are similar to oil and gas operations, only in reverse. Instead of reducing the reservoir pressure by production, the reservoir pressure is increased by injection. This is similar to natural gas storage fields in saline formations. It is also similar to secondary (water flooding) and tertiary production operations (Enhanced Oil Recovery) but the pressures here are not as high in these two scenarios. Transportation and injection of CO_2 for EOR operations has been done since the early 1970s. Technology utilized for sequestration comes from the oil and gas industry. However, instead of looking for hydrocarbons, this technology will be used to monitor and track CO_2 in the subsurface. Much of the technology is proven, but its application is different. Significant work is underway to test the application of oil and gas technology in CO_2 sequestration operations, most notably by the regional partnerships assembled by the DOE/NETL. The risks associated with oil and gas operations are well understood. These risks are similar to those in CO_2 sequestration operations. The significant difference here is in assuring retention of the CO_2 in the subsurface over a considerable period of time.

Given economic feasibility, the rate at which storage fields can be permitted and brought online will dictate the rate of deployment for CCS technology. Without storage, there is no need for capture.

I.E. LEGAL SUBCOMMITTEE

The efforts of the Legal Subcommittee began by undertaking a careful review of activities around the country in identifying significant policy, regulatory and legal issues raised by CCS projects. After identifying the universe of issues involved, initial efforts focused on property ownership and acquisition. Research was conducted on activities in other states and by such organizations as the Interstate Oil and Gas Compact Commission, CCSReg and the

Midwest Governors Association. In addition, an evaluation was conducted of the consequence of allowing the current legal process already in place to control the acquisition of land to be used for a CCS project. The goal of this effort was to explore all options in order to create a solution tailored to West Virginia legislature's desire to site commercial scale CCS projects.

The Legislature has requested the Working Group to make recommendations to encourage the development of CCS and to examine factors integral to the construction, maintenance, and operation of CCS facilities, among other things. In response to this request, the Working Group turned its initial attention to the manner in which pore space rights are to be acquired.

The resulting analysis focused principally on two overarching factors: (1) the practicality and cost of any approach that required that all owners of pore space be identified and paid for the right to use pore space without regard to the landowners potential for use of the pore space, and (2) the constitutional requirements applicable to the circumstances under which the use of land required compensation as a taking.

With respect to the first of these factors, the Working Group recognizes that in West Virginia and much of the East, the number of property owners that could be within the footprint of a CCS project could be extremely large. It is assumed that a full scale CCS project could encompass an area the size of Mason County, West Virginia. In Mason County alone, there are nearly 20,000 surface owners and 1,000 mineral owners. On the conservative assumption that a typical title examination could cost $5,000 per tract, the cost to do title searches for a project with a footprint this large would be approximately $100 million. Added costs related to compensation to landowners and transactional costs related to acquiring the property rights cause the Working Group to conclude that an alternative course of action should be pursued.

Turning then to the constitutional requirements related to compensation for the use of land, the Working Group recognizes that not all use of private land results in a compensable taking. The United States Supreme Court and other courts have recognized a number of circumstances in which compensation was not required to be paid for the use of land. These cases have included in certain circumstances airplane over-flights of land and injection of material into underground foundations. By reviewing the facts and circumstances surrounding these cases, the Working Group has developed a statutory mechanism that is believed to pass constitutional muster.

The approach of dedicating certain pore space below 2,500 feet to public use is the pore space use approach favored by the majority of the Working Group at this time.

The Legal Subcommittee has also addressed in this report such additional issues as:

1. Permitting.
2. Groundwater Protection.
3. Fees.
4. Interstate Projects.
5. Preemption.
6. Report to Legislature.
7. Liability transfer.
8. Post Closure Trust Fund.
9. PSC Approval.

10. Ownership and Value of Stored CO_2.
11. Amalgamation of Property Rights.
12. Pipelines.
13. Restrictions on the Use of Mineral Bearing and Other Formations.
14. Other WVDEP Authority.
15. Primacy of the Mineral Estate.
16. Inverse Condemnation.
17. Role of ALJs.
18. Continued Role of the Working Group.
19. Penalties.
20. Severability.
21. Confidentiality.

I.F. SUMMARY

Much research has been conducted by the Working Group through its subcommittees over the past two years. The subcommittees studied current law, emerging technologies, and the work of similar entities created in other states. The Working Group tackled the difficult and controversial issues and hurdles to aggressive deployment of CCS in West Virginia. The Working Group appreciates the assistance by way of resources including accommodations, personnel, and data offered by the WVDEP and the WVGES.

II. DETAILS OF THE WORKING GROUP

II.A. MEETINGS

The full Working Group's first meeting occurred on August 12, 2010. During that meeting, the Group elected Stephanie R. Timmermeyer to Chair the Group and Tim Grant as Vice-Chair. The Legislature identified ten items in the W.Va. Code § 22-11A-6(h)(1)-(10) for inclusion in the Working Group's Final Report to the Legislature. The Working Group formed three committees because the list of ten items identified by the Legislature may be categorized into three discrete areas: feasibility, geology and technology, and legal.

The Feasibility Subcommittee is tasked with items 1, 2, 4, 7, 9, and 10 (with an emphasis on items 1, 2, 4, and 7). In addition, the Group asked this subcommittee to consider transportation and public outreach. Members consist of Tim Mallan, Chair, Cal Kent, Jim Laurita, Earl Melton, Stephanie Timmermeyer, and Vickie Wolfe.

The Geology and Technology Subcommittee is responsible for items 2, 5, 6, 8, 9, and 10 on the task list (with an emphasis on items 5, 6, and 8). Members include Tim Grant, Chair, Grant Bromhal, Leonard Knee, Paul Kramer, and John Leeson.

The Legal Subcommittee is responsible for items 2, 3, and 10 (with an emphasis on item 3). In addition, the Group asked this subcommittee to consider issues related to liability. Members include David Flannery, Chair, Alan Dennis, Richard Winschel, Dave McMahon, and Nick Carter (Greg Wooten).

The three subcommittees met numerous times in person and via phone conference. The full Working Group also met on several occasions.

II.B. RESOURCES

As stated in the Foreword, the Working Group reviewed a substantial body of data and reports related to various aspects of carbon capture and sequestration. This Final Report incorporates or refers to data and information from a large number of sources including federal and state agencies, and non-governmental organizations. Some of this data and information may be incomplete or inaccurate. The citation to these sources does not necessarily mean the Working Group agrees with the data, information, or opinions cited.

A webpage was created on the WVDEP's website to post these resources, minutes from the meetings, subcommittee reports, and presentations of various speakers. The link is http://www.dep.wv.gov/executive/Pages/ccsworkinggroup.aspx.

III. STATUS OF THE REGULATION OF GREENHOUSE GASES

Even in advance of Congressional activity related to CO_2 emissions, many legislative, regulatory and judicial activities are underway at the state and federal level which have as their objective reducing the amount of CO_2 emitted to the atmosphere.

On April 2, 2007, the U.S. Supreme Court held in *Massachusetts v. EPA*, 549 U.S. 497 (2007), that GHGs are air pollutants covered by the Clean Air Act ("CAA"). The Court also held GHG emissions are subject to CAA section 202(a) under which the USEPA Administrator must determine whether or not emissions of GHGs from new motor vehicles or motor vehicle engines cause or contribute to air pollution, which may reasonably be anticipated to endanger public health or welfare, or whether the science it too uncertain to make a reasoned decision. This decision was precipitated by a petition for rulemaking filed by environmental, renewable energy, and other advocacy organizations.

Following the U.S. Supreme Court's decision in *Massachusetts v. EPA*, a flurry of findings and proposed regulations paved the way for future regulation of GHGs under the CAA.

Also in response to the *Massachusetts v. EPA*, decision, USEPA proposed a finding that GHGs from new motor vehicles or motor vehicle engines cause or contribute to air pollution that may endanger public health or welfare. As described in the "Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act," 74 FR 18886, April 24, 2009, summary:

> Today the Administrator is proposing to find that greenhouse gases in the atmosphere endanger the public health and welfare of current and future generations. Concentrations of greenhouse gases are at unprecedented levels compared to the recent and distant past. These high atmospheric levels are the unambiguous result of human emissions, and are very likely the cause of the observed increase in average temperatures and other climatic changes. The effects of climate change observed to date and projected to occur in the future—including but not limited to the increased likelihood of more frequent and intense heat waves, more wildfires, degraded air quality, more heavy downpours and flooding, increased drought, greater sea level rise, more intense storms, harm to water resources, harm to agriculture, and harm to wildlife and ecosystems—are effects on public health and welfare within the meaning of the Clean Air Act. In light of the likelihood that greenhouse gases cause these effects, and the magnitude of the

> effects that are occurring and are very likely to occur in the future, the Administrator proposes to find that atmospheric concentrations of greenhouse gases endanger public health and welfare within the meaning of Section 202(a) of the Clean Air Act.
>
> She proposes to make this finding specifically with respect to six greenhouse gases that together constitute the root of the climate change problem: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

This is referred to as the "endangerment finding."

> The Administrator is also proposing to find that the combined emissions of carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons from new motor vehicles and new motor vehicle engines are contributing to this mix of greenhouse gases in the atmosphere. Thus, she proposes to find that the emissions of these substances from new motor vehicles and new motor vehicle engines are contributing to air pollution which is endangering public health and welfare under section 202(a) of the Clean Air Act.

This is referred to as the "cause or contribute finding."

Finalization of the endangerment finding in December, 2009, authorized the agency to promulgate GHG control regulations for all sources of emissions. (74 Fed. Reg. 66,496 Dec. 15, 2009). The promulgation of USEPA's Motor Vehicle Rule in May 2010 triggered an obligation for the agency to regulate stationary sources of GHG emissions under the PSD and Title V permitting programs. In April, 2010, USEPA established a phase-in schedule for stationary source GHG obligations under the PSD program. 75 Fed. Reg. 17,004 (April 2, 2010).

On June 3, 2010, the USEPA published the final version of its "Prevention of Significant Deterioration (PSD) and Title V Greenhouse Gas Tailoring Rule" (75 Fed. Reg. 31,514), which establishes greenhouse gas emission requirements for stationary sources subject to the federal Clean Air Act PSD and Title V programs. The Tailoring Rule is one of several actions being taken by USEPA in response to the U.S. Supreme Court's 2007 decision in *Massachusetts v. EPA* that the USEPA must regulate GHG emissions under the federal Clean Air Act if the agency determined that such emissions endanger the public health or welfare. The USEPA promulgated the Tailoring Rule to avoid the "absurd consequences" the agency itself identified would result from subjecting stationary sources of GHGs to the existing parameters of those programs.

Draft, non-binding guidance issued by USEPA on November 10, 2010, discusses how carbon capture and sequestration (CCS) should be evaluated as a Best Available Control Technology (BACT) under the PSD, concluding that while CCS is a "promising technology," EPA does not believe that at this time [it] will be a technically feasible BACT option in certain cases. The guidance suggests that oil and gas processing plants must consider CCS as part of BACT consideration. *See*, PSD and Title V Permitting Guidance for Greenhouse Gases, *available at*, http://www.federalregister.gov/articles/2010/11/17/2010-28962/psd-and-title-v-permitting-guidance-for-greenhouse-gases Additionally, USEPA announced in December 2010 its intent to develop NSPS to control GHG emissions from power plants, which are estimated to take effect in 2012.

On December 10, 2010, the USEPA issued the final injection well regulations under the Safe Drinking Water Act's (SDWA) Underground Injection Control (UIC) program that would apply to CO_2 geological sequestration (GS) wells. The rule is designed to primarily protect underground sources of drinking water (USDW). The SDWA mandates that each state must have an UIC program[7]. The final rule established a new UIC well class -- Class VI – for injection wells that will be used to inject CO_2 into the subsurface for the purpose of long-term storage; the final rule also specified that GS could occur in UIC Class II, which is currently used for EOR, if certain circumstances are met. The final rule sets minimum technical criteria for the permitting, geologic site characterization, area of review and corrective action, financial responsibility, well construction, operation, mechanical integrity testing, monitoring, well plugging, post-injection site care, and site closure of Class VI wells for the purposes of protecting underground sources of drinking water USDWs.

Significantly, the SDWA was enacted to protect public health through regulations designed to protect USDWs. The SDWA does not grant authority to the USEPA to regulate other potential legal impediments to CCS[8], such as pore space rights and long-term liability.

USEPA also published guidance in December 2010 regarding financial responsibility for Class VI wells. It provides recommended types of financial mechanisms to be used to meet the new Class VI well requirements. *See*, Financial Responsibility Document, *available at* http://water.epa.gov/type/groundwater/uic/class6/upload/uicclass6financialresponsibilityguidancedec2010.pdf

To complement the UIC Class VI program, USEPA issued the Final Mandatory Reporting of Greenhouse Gases from Carbon Dioxide Injection and Geologic Sequestration Rule in November 2010. Subpart RR of this rule requires CCS facilities to report GHG data annually. This rule requires CCS facilities to develop and implement a site-specific monitoring, reporting and verification ("MRV") plan, and to report the amount of carbon dioxide sequestered using a mass balance approach. Mandatory Reporting of Greenhouse Gases from Carbon Dioxide Injection and Geologic Sequestration Rule, 75 Fed. Reg. 75060 (Dec. 1, 2010). Compliance with this rule will allow GS operators to provide proof of sequestration, eliminating yet another a barrier to CCS.

The USEPA's regulatory initiatives are the subject of multiple legal challenges that may require many months to resolve. These and other climate change initiatives will undoubtedly continue to play out, even as the Working Group continues to address the issues related to CCS.

At the state level, it is clear that CCS will play an important role in preserving West Virginia's economy that heavily relies on the exploitation of fossil fuels. The Carbon Dioxide Sequestration Act, W.Va. Code § 22-11A-1 et seq., was passed by the legislature in 2009. The West Virginia Legislature also passed the Alternative Generation Portfolio Standard bill which sets targets for electric utilities to provide for a mix of traditional and alternative sources of electricity. This legislation creates not only incentives for renewable sources of energy, but also electricity generation using alternative methodologies, including CCS.

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[7] *See Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO2) Geologic Sequestration (GS) Wells, Final Rule, available at,* http://www.gpo.gov/fdsys/pkg/FR-2010-1210/pdf/2010-29954.pdf (Dec. 10, 2010).

[8] *See* U.S. EPA publication, *Understanding the Safe Drinking Water Act*, at http://www.epa.gov/safewater/sddwwa/pdfs/fs_30ann_sdwa

IV. SUBCOMMITTEE REPORTS

IV.A. FEASIBILITY SUBCOMMITTEE REPORT

IV.A.1. Introduction

The decision as to whether individual West Virginians or other greenhouse gas generators in West Virginia will be required to reduce emissions of these materials is apparently, at this time, not something the Legislature will be able to control. The U.S. House of Representatives passed a comprehensive bill in June 2009 (American Clean Energy and Security Act of 2009). There is no current House or Senate action on this type of legislation, but there remains the possibility of renewed efforts to implement such legislation. In addition**,** USEPA is proceeding on the basis of the *Massachusetts v. EPA* to promulgate regulations that would require the control of greenhouse gas active materials.

Internationally a number of nations have embarked on programs to require reductions in the emissions of greenhouse gases in response to the Kyoto Protocol and many nations, including the United States, are actively involved in programs to mandate additional greenhouse gas emissions.

With the understanding that reductions in greenhouse gas emissions may be imposed on West Virginia sources, the Feasibility Subcommittee ("FSC") provides discussions of the following issues to the Legislature for its consideration.

Using W.Va. Code §22-11A-6(h) as a guide, the FSC was assigned the task of developing information and discussion of all or part of the following subsections:

(1) Recommend appropriate methods to encourage the development of carbon dioxide sequestration technologies;
(2) Assess the economic and environmental feasibility of large, long-term carbon dioxide sequestration operations;
(4) Recommend methods of facilitating the widespread use of carbon dioxide sequestration technology throughout West Virginia; and
(7) Assess the costs, benefits, risks and rewards of large- scale carbon dioxide sequestration projects in West Virginia.

The Feasibility Subcommittee discusses these issues in Section A.2. through A.7 as follows:

A.2. Background - The Magnitude of the Task
A.3. Is CCS Feasible for West Virginia?
A.4. Cost of Various Technologies and Estimating the Economic Impact of Implementing CCS in West Virginia.
A.5. Environmental and Health Related Factors.
A.6. Incentives for CCS Technology.
A.7. Conclusions and Recommendations Being Discussed for the Final Report.

IV.A.2. Background – The Magnitude of the Task

Due to the presence of coal based electric generators in West Virginia the state is able to provide all the electric power needed to meet its own needs and is the second largest provider of electric power for export to other states.[9] West Virginia also produces the majority of its electric power by burning coal,[10] a process that releases more greenhouse gas in the form of CO_2 than other commonly used methods of power generation.[11] In view of the relatively large amount of CO_2 produced in the state and the contribution of coal production and utilization to the economy, the West Virginia Legislature should be aware of the impact that requirements for significant reductions in CO_2 could have on the state.

It is likely that sources in West Virginia will be faced with having to reduce CO_2 emissions over the next few years by significant amounts. Currently there is no method to make such reductions without either curtailing in-state generation or constructing new lower carbon or zero carbon power plants. However, the development of CCS technology could allow West Virginia to continue as a major coal producing and electrical power exporting state.

As of October 2009 West Virginia became the first place in the world in which a slipstream carbon capture and geological sequestration facility associated with a commercial coal-fired electric power plant was replaced into operation[12]. A great deal of operational and technical knowledge is being gained from this new facility. The state now has the opportunity to take part in the development of the administrative and legal processes needed to make this technology a useful tool for addressing greenhouse gas reduction throughout the world. This section of the report discusses the magnitude of the challenge to reduce CO_2 from a state, national and international perspective.

The West Virginia legislature can help set the course for the actions to be taken by the state to answer this challenge. The Legislators should be aware of two important factors in addressing these challenges. First these challenges will require significant changes to be accomplished within the state. Second, these challenges may present many opportunities for the state to use our natural, human and intellectual resources in a manner that benefits our citizens.

In the area of challenges, consider, for instance, the requirements that would be imposed on power generation in West Virginia by the proposed American Clean Energy and Security Act of 2009(ACES)[13] which was passed by the U.S. House of Representatives in June of 2009. In essence, this act would require that total greenhouse gas emissions in the US from specified sectors of the economy should be reduced by 3% in 2013, 17% by 2020, 42 % by 2030 and 87% by 2050.[14] The base year for these percentage reductions is 2005, a year in which US Total GHG emissions were 7206 Mt CO_2 eq.[15]

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[9] West Virginia Energy Profile – USDOE EIA, retrieved 11/30/09. http://www.eia.gov/state/state-energy-profiles.cfm?sid=WV

[10] Ibid

[11] USDOE EIA Frequently Asked Questions – Environment, list of CO_2 emissions for various fuels per BTU. http://tonto.eia.doe.gov/ask/environment_faqs.asp#CO2_quantity retrieved 11/30/09.

[12] AEP/APCo Mountaineer Plant CCS Process Validation Project, Mason Co., WV

[13] For a short discussion of ACES see article in Wikipedia at: http://en.wikipedia.org/wiki/American_Clean_Energy_and_Security_Act This article also reports acronym as ACES although some sources Quote as ACESA.

[14] American Clean Energy and Security Act of 2009 - HB 2454 (as placed on Senate Calendar) Title VII, Section 703.

[15] For the purpose of this discussion when talking about emissions of CO_2, the term "Mt" (million metric tonnes) will be used as opposed to emissions of all GHGs which are reported in terms of Mt CO_2eq (CO_2 equivalent includes the emissions of the other so-called Kyoto greenhouse gases reported as the product of their actual tons emitted and the gas's global warming potential(GWP). Thus 1 ton of methane is reported as 21 tons of CO_2eq since the GWP for methane = 21). To confuse matters further, most listing of total emissions is now being reported internationally in terms of teragrams (Tg) of CO_2eq. A teragram is, however, equal to 1 million metric tons.

To put these challenges in perspective, assume that West Virginia sources are required to reduce emissions by the percentages specified in the Act. As shown in the attached Table A.1, in 2007 West Virginia coal-fired power plants emitted approximately 85.6 million metric tons of CO_2 and in the base year of 2005 emissions from coal-fired electric production amounted to 84.1 Mt.[16]

Under the proposed ACES legislation, West Virginia sources would be required to reduce CO_2 emissions by approximately 2.52 Mt in 2012, 14.28 Mt in 2020 and 35.32 Mt by 2030. Note the allowance allocations available each year during the interims between these target dates also decline on a sliding scale (for instance in 2014 there would be a requirement for a 7.3% reduction from 2005 emissions). As an alternative the state's generators could purchase offsets under the "cap and trade" program provided in the Act.

On a national basis HR 2454 would limit emissions from certain sources to only 4,627 Mt in 2012, 5,056 Mt (from a broader list of sources) in 2020 and 3,533 Mt in 2010 from "capped sources" (which include coal-fired power plants).[17] Note that the allowed emissions allocations do not recognize any growth in electrical demand.[18]

[16] USDOE EIA. State Historical Tables for 2008 Emissions by Energy Source, January 21, 2010 .http://www.eia.doe.gov/cneaf/electricity/epa/emission_state.xls

[17] Note that the rise in allowances in 2020 is due to an increase in the types of sources that are to be considered to be in the capped category between 2012 and 2020.

[18] The Energy Information Agency projects that in years 2008 through 2035 electrical demand in the US will increase at a rate of about 1% / year. Coal generation capacity would increase by about 24 GW using the assumptions used in their analysis. EIA admits that economy and concern about GHG emissions could significantly change that projection. USEIA, "Annual Energy Outlook 2010," Electrical Generation, December 2009. http://www.eia.doe.gov/oiaf/aeo/overview.html ,(Accessed 2/9/10)

TABLE IV.A.1[19]

Some important numbers when considering emissions of Greenhouse Gases.

Electric Power Produced in US	4156 TWh[20 21]
Electric Power Produced by Coal in US	2016 TWh[22]
World Production of Electric Power	18,778 TWh[23]
World non-Hydro Renewable Production	473 TWh[24]
West Virginia Coal-fired Electric Power	94 TWh[25]
West Virginia Renewable Power (Wind)	0.168 TWh[26]
Amount of CO_2 emitted in US Energy Production	5912 Mt[27]
Amount of CO_2 emitted by US coal-fired electric power	2155 Mt[28]
World Coal-fired Electric Production CO_2	12,496 Mt[29]
West Virginia Coal-fired Electric Power CO_2	85.6 Mt[30]
Total US GHG Emissions	7150 Mt CO_2eq[31]
Total World CO_2 Emissions (Anthropogenic)	29,914 Mt[32]

Options Available To West Virginia to Reduce CO_2 Emissions

While reductions in any listed greenhouse gas will count toward achieving the reductions required in the ACES proposal, the reductions most likely to occur in West Virginia will involve reductions in CO_2.[33] While technology is developing almost daily a number of facts should be

[19] All data in this table is based on calendar year 2007, unless otherwise noted.

[20] A terawatt hour (TWh) is the amount of electrical power meeting a demand of 1 trillion watts for one hour. 1 TWH equals 1 million megawatt hours or 1 billion kilowatt hours, all of these terms are commonly used to designate large quantities of electrical power. To put this measure into perspective, 1 TWh is the amount of electrical power that would be used by a 100 watt incandescent light bulb if it burned continuously for approximately 1.2 million years.

[21] USDOE EIA. Net Generation by Energy Source, May 14, 2010. http://www.eia.doe.gov/cneaf/electricity/epm/table1_1.html.

[22] Ibid.

[23] USDOE EIA. International Energy Statistics – Coal - Generation http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=12

[24] Reference is listed as *Non-hydro* as hydro is not considered to be renewable in many definitions. USDOE EIA. International Energy Statistics – Generation - Renewables http://tonto.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=34&aid=12&cid=&syid=2004&eyid=2008&unit=BKWH&products=34

[25] USDOE EIA. State Historical Tables for 2008 – Generation by Energy Source http://www.eia.doe.gov/cneaf/electricity/epa/generation_state.xls

[26] Ibid

[27] Includes all energy production, electric generation, transportation, etc. USDOE EIA. Emissions of Greenhouse Gases Report – 2008, December 3, 2009. Table 5 Emissions of Carbon Dioxide for Energy and Industry. http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html#total

[28] Ibid.

[29] USDOE EIA. International Energy Statistics - Coal –Generation – CO_2 Emissions http://tonto.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=&syid=2003&eyid=2007&unit=MTCD&products=1

[30] USDOE EIA. State Historical Tables for 2008 Emissions by Energy Source, January 21, 2010 http://www.eia.doe.gov/cneaf/electricity/epa/emission_state.xls

[31] USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007 Executive Summary p. 6, April, 2009.SDOE EIA. http://www.epa.gov/climatechange/emissions/downloads09/ExecutiveSummary.pdf

[32] Note this is only for burning of fossil fuels, other GHGs not included. See: USDOE EIA. H.1co2 World Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980-2006 http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls

[33] The West Virginia 2005 baseload value represents the best estimate of total GHG emissions according to the Energy Information Agency. ACES does not specify the actual 2005 emissions to be used in determining individual compliance limits, only the national total of 7206 Mt. While demonstrated reductions in other GHG gases would yield larger reduction credit than

borne in mind when looking at the options available to West Virginia CO_2 sources to achieve the reductions envisioned in this proposal.

Assuming there is some required reduction based on the timetable in the ACES proposal:

- In 2012 there is no technology currently forecast to be commercially available to actually remove CO_2 from the emission stream of coal-fired power plants.
- If ACES is able to move through the legislative process with most of its current language intact, there will be opportunity for much of the early compliance to be met by the use of offsets, which would allow West Virginia coal-fired sources to continue to operate.[34]
- West Virginia utilities could back off in-state generation and either build zero carbon generation or purchase such generation from others (including out of state sources).[35]
- West Virginia could reduce electrical demand by the percentages listed in ACES but would also have to increase the amount of reduction to account for any growth in demand.
- With each year seeing increasing requirements for reductions at some point actual reductions in the emissions of CO_2 from West Virginia sources would have to be accomplished.

What Carbon Capture and Sequestration Means

Carbon capture and sequestration is a technology that would remove carbon in the form of CO_2 from the emission stream of a power plant and store the removed material in a manner that would prevent it from entering the atmosphere or ground water. Methods being investigated for carbon capture have looked at either biological processes, using some form of living organisms that utilize CO_2 as a carbon source, or chemical processes which use a chemical reaction that absorbs or incorporates $CO_{2.}$

It is possible to design bioreactors that use living organisms to synthesize molecules that can be further processed into carbon-based fuel which can replace fossil based fuel. An example of such a process would use CO_2 captured from a power plant emission stream to enhance production of specific types of algae. The algae could then be processed into material that could be substituted for fossil fuel. The net effect would be a reduction in CO_2 emission.

Another possible biological sequestration strategy involves the uptake and long-term storage of carbon in biomass such as trees. This postpones the release of greenhouse- active materials to a point in the future. This type of storage requires some guarantee that the biomass is not handled in manner that would rapidly re-introduce the captured $CO_{2.}$ [36]

CO_2 (e.g. 1 ton methane reduction = 21 tons CO_2 reduction) a discussion of CCS involves only CO_2 as this technology has not been proposed for other GHGs. If other deductions are shown to be feasible the impact of such deductions would proportionally lessen needed lowering of CO_2 quantities.

[34] ACES Title VII, Part D – OFFSETS

[35] For instance using WV's total 2007 production of 94 TWh and emissions of 85.6 Mt (see Table A.1) gives a state average of 0.91 Mt/MWh. With a reduction of 2.52 Mt needed for 2012, state utilities would have to reduce output by 2.77 TWh in 2012 and 15.70 TWh in 2020. It appears that WV would have to increase renewable generation by a significant amount (see Table IV.A.1) to provide in-state generation to replace idled coal power.

[36] See for instance WORKING PAPER ON CARBON SEQUESTRATION SCIENCE

In general, chemical capture processes have come to focus on the geological storage of the captured material. In this process, captured CO_2 in a supercritical or dense phase is pumped underground to reside in a geological stratum that has been demonstrated to have the capacity to hold the material for very long time periods (thousands to millions of years).[37]

Biological capture and storage is a developing field of scientific interest. The Working Group feels that for this method of achieving greenhouse gas reduction any requirements the state may have to meet should not be ignored. The Working Group would encourage the state to support such research and development. However, the Working Group interprets the focus of W.Va. Code Chapter 22 Article 11A to be centered on the geologic sequestration of CO_2.[38] This report will therefore concentrate on techniques involving the capture of CO_2 from power plant emissions and the geologic storage of the captured CO_2.

Is There a Need For CCS?

Many references have stated that the development of CCS technology is critical to achieving the goal of reducing the emissions and atmospheric concentration of greenhouse gases. For instance in expressing disappointment with a decision by the Mississippi Public Service Commission to severely restrict funding for Southern Company's proposed IGCC plant with CCS, the position of Secretary of the Department of Energy, Stephen Chu, was described in Energy Daily as follows:

> "The energy secretary said the nation has to build large-scale CCS projects that will allow the continued use of coal in a carbon-constrained regulatory environment. 'Nothing ranks as high as CCS . . . among the tools that could be used to decrease carbon emissions,' Chu said. He acknowledged that that CCS projects are 'very costly and expensive,' but added: 'I think we have to push ahead.'"[39]

A look at the magnitude of CO_2 emissions listed in Table A.1 gives some idea of the amount of CO_2 that is emitted from electrical production on a worldwide, national and West Virginia basis. West Virginia coal-fired plants emitted 85.6 Mt of CO_2 in 2007 and, according to the timetable in ACES, would have to reduce that to roughly 50 Mt by 2030. The nation would have to reduce CO_2 from coal-fired plants by at least 908 Mt in that time frame. If the world were to try to meet the same reduction schedule, world coal-fired power would have to reduce emissions by another 4,800 Mt from current coal emission rates. Worldwide it is estimated that by 2030 overall coal use will increase to a level approximately 1.6 times the amount used in 2004. [40]

AND TECHNOLOGY, Office of Science, Office of Fossil Energy, U.S. Department of Energy, February 1999, available at: http://www.netl.doe.gov/publications/press/1999/seqrpt.pdf for an extensive discussion of the whole issue of biological sequestration.

[37] There are a lot of documents available dealing with geological sequestration. One of the most comprehensive references that is often quoted is IPCC Special Report on Carbon Dioxide Capture and Storage, Bert Metz, et al, Prepared by Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2005

[38] §22-11A-1(12) states that development of carbon dioxide capture and sequestration technologies is in the public interest. §22-11A-2(b) then defines Carbon dioxide sequestration as "…the injection of carbon dioxide and associated constituents into subsurface geologic formations intended to prevent its release into the atmosphere."

[39] Energy Daily "Chu Urges Mississippi Regulators. Southern Co. To Reach IGCC Deal." Friday, May 7, 2010 ED Vol. 38, No. 86 p. 4

[40] World Energy Council, "2007 Survey of Energy Resources" p. 2. The council projects that coal use would increase from 2772 mtoe in 2004 to 4441 mtoe in 2030. (mtoe = million tonnes of oil equivalent).

In any discussion of world emissions, China is often of peak interest due to the fact the country exhibits the most significant emissions growth of any country in the world. China is now the world's largest CO_2 producer and user of coal in electric generation[41]. Between 2008 and 2009 China's net generation of electricity increased by 6%[42]. China's consumption of coal is forecast to more than double by 2035[43]. In addition to China most of the increase in coal generated electricitiy will come from India and other fast-growing Asian nations[44].

With so much coal-fired generation capacity currently installed and much of this capacity still brand new, especially in developing nations, much of the physical plant devoted to coal-fired power generation is likely to continue in service. Generally newly constructed power plants are expected to operate for 30 to 50 years. In an era in which reduction of CO_2 emissions is seen as critical, CCS provides a method to preserve this critical infrastructure and still make progress toward reducing greenhouse gas emission. The World Resources Institute states in the Executive Summary to its Guideline for Carbon Dioxide Capture, Transport, and Storage:

> "CCS is a critical option in the portfolio of solutions available to combat climate change, because it allows for significant reductions in CO_2 emissions from fossil-based systems, enabling it to be used as a bridge to a sustainable energy future."[45]

Is CCS the *"Only"* Solution to Climate Change?

The West Virginia Legislature must be clear on one very important point about CCS. No one who has a firm understanding of the challenges facing the state in trying to find a solution to reconciling the world's energy needs with the desire to reduce atmospheric concentrations of greenhouse gases is proposing that CCS is the "only" solution to climate change. CCS is a method that if effectively demonstrated and widely deployed could have dramatic and potentially permanent impact on the emissions of CO_2 from large stationary sources. But with coal-fired electric production accounting for roughly 42% of world anthropogenic CO_2 emissions (see Table 1), even a total and immediate cessation of all coal-fired electric production (a totally impossible occurrence) would fall short of the 50% reduction by 2050 in human emissions identified as a combined US/European Union goal in the November 3, 2009 EU/US Summit meeting in Washington DC.[46]

Nor is CCS the least expensive of the many options identified for the reduction of greenhouse gas emissions.[47] For instance, The McKinsey Report proposes that on a per ton basis, CCS is not the least expensive method of reducing GHG emissions by a very large margin. However, in looking at the amount of greenhouse gas reduction being proposed by many authorities, some will conclude that even with the employment of all the easier and less expensive methods of reduction there will still be a pressing need for even some of the most expensive technologies.

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http://www.worldenergy.org/documents/ser2007_final_online_version_1.pdf

[41] EIA Country Overview_China. http://www.eia.gov/countries/county-data.crm?fips.CH

[42] Ibid.

[43] Ibid.

[44] EIA International Energy Outlook April 2011, http://www/eia.gov/ciaf/ieo/html

[45] World Resource Institute, Guidelines for Carbon Dioxide Capture, Transport, and Storage, 2008, p.8

[46] 2009 EU – US Summit Declaration, accessed 11/25/09, available at: http://ec.europa.eu/external_relations/us/sum11_09/docs/declaration_en.pdf

[47] See for instance McKinsey & Company Reducing U. S. Greenhouse Gas Emissions: How Much at What Cost, December 2007, Executive Summary, U.S Mid-Range Abatement Curve 2030 p. xiii.

Wedge Stabilization Analysis

To understand the magnitude of this effort, the Legislature needs to look at the multiple factors involved in a total remake of the electric power system in the state, in the nation and in the world. S. Pacala and R. Socolow of Princeton University proposed the now-famous Stabilization Wedges process of looking at how current technology could address the challenge of climate change.[48] The authors looked first at the levels of rising emissions over the last 50 years. They then projected what the atmospheric concentration would be in the 2050s assuming the same rate of increase as the historical data. Using the result they had calculated, they postulated the employment of existing technologies that would be needed to reach a concentration in 2050 that did not exceed the level reached in 2004. In other words, their proposal would not reduce emissions but only recreate the emissions level that existed in 2005.

The analysis shows that by 2050 the technologies employed would have to result in a total worldwide reduction of 8 billions tons per year of CO_2eq. The authors then assigned to each of 8 specific strategies an annual reduction goal of 1 billion tons each. On a graph each of these goals develops into a wedge shaped figure that starts representing a small deployment of the technology which reaches 1 billion tons in 2050 as the technology is more widely adopted. The basic idea is to achieve a lifestyle for all the world's inhabitants that approaches that common in the western world and still meet the projected greenhouse gas emissions goals.

Over the roughly 50 years of the process each wedge represents a total reduction equal to 25 billion tons. Different technologies are then analyzed to determine what level of deployment of the technology would be needed to achieve one wedge. For instance, replacing every single incandescent light bulb in the entire world with CFLs would yield ¼ of one wedge. For CCS to achieve a single wedge it would have to be installed at 800,000 MW of coal-fired power plants. Currently this would equal the total number of coal plants in the U.S. plus almost all the generation capacity of China (regardless of power source). The authors note that at the time of the report there were three projects in the world (all were natural gas treatment projects) injecting 1 Mt/year each. By 2055 there would have to be 3500 such projects to achieve one wedge.

Other technologies that would equal one wedge:

- Efficiency – Double the fuel efficiency of every automobile on earth or reduce the total numbers of miles driven by ½.
- Efficiency – Double the efficiency of all plants producing electrical power but keep electrical demand at its current level.
- Fuel Switching – (Note CCS is included in this category) Replace 1400 coal-fired power plants by an equal number of natural gas plants.
- Renewables – Replace an equivalent capacity of coal-fired plants by 1 million wind turbines each with a capacity of 2 MW.
- Renewables – Replace an equivalent capacity of coal-fired plants with 20,000 square kilometers of solar panels. [49]

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[48] Pacala, Stephen W., and Robert H. Socolow, 2004: *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*. *Science*, **305**, doi:10.1126/science.1100103 968-972

[49] To learn more about Wedge Stabilization see the web page at: http://cmi.princeton.edu/wedges/
for a quick PowerPoint see: http://cmi.princeton.edu/wedges/Wedges_slides_8.ppt#12

This analysis lists 15 different technologies that the authors consider to be currently available and notes that no technology would have to necessarily supply an entire wedge on its own for the program to achieve its goals. Any combination of methods contributing either parts of or multiple wedges could be employed to achieve the stabilization desired. It should be noted again that this analysis would not achieve an emission reduction below the 2005 baseline. It would only preserve the emissions status quo of the base year.

The Wedge Stabilization discussion illustrates the important point that any reduction scheme is going to have to utilize multiple tools. But all reduction strategies have to take into account the growing electrical demand in a world where over 1.6 billion people still have no access to electrical power.[50]

West Virginia is already in the lead by virtue of having the first coal-fired power plant CCS project in the world operating in Mason County. A project such as this, along with others being planned and developed around the world, may be able to demonstrate that CCS can have an immediate and lasting impact on atmospheric carbon content. The state is in the position to learn much about how such a project actually will work. The opportunity to help develop the administrative processes, laws and regulations that will be a model for others to follow is in the hands of the West Virginia Legislature.

IV.A.3. Is CCS Feasible for West Virginia?

With the acknowledgement that there is a significant probability that CCS is likely to be one of the methods needed to achieve the greenhouse gas reduction goals the world and the nation are likely to set the questions to be considered by West Virginia may be summarized as follows:

1. What factors need to be considered in determining if CCS is feasible and beneficial for West Virginia?
Question 1 is addressed in this section and Section A.4

2. What factors need to be addressed to be able to assure the citizens of West Virginia that CCS is safe in terms of human health and the environment?
Question 2 is addressed in Section A.5.

3. What are the technical issues (both engineering and geological) that must be addressed to ensure the efficacy of CCS in West Virginia?
Question 3 is addressed in Section IV.B.

4. What legal and liability issues need to be decided before CCS can be pursued in West Virginia?
Question 4 is addressed in Section IV.C.

5. If the Legislature were to decide that CCS would be beneficial to West Virginia, what actions should be to ensure the realization of these benefits for the citizens of the state?

The Working Group suggests that the following factors will have to be considered by the West Virginia Legislature before an informed decision can be made.

- Will West Virginia have a need for CCS?

[50] USDOE EIA. International Energy Outlook 2009, Chapter 5 – Electricity, May 27, 2009 http://www.eia.doe.gov/oiaf/ieo/electricity.html, accessed 12/1/09.

- If so, when will that need become a reality?
- What is currently available to meet such a need using CCS?
- Are there alternatives to CCS for meeting those needs?
- What are the projected costs and benefits to West Virginia and how do these compare with the costs and benefits of alternatives?

Looking at these factors individually the Working Group offers the following discussion.

Will West Virginia have a need for CCS?

Earlier in this report there was a discussion of the probability for CO_2 emission reductions in the near future. West Virginia currently has 14,715 MW of coal-fired power plants and approximately 39 utility-owned coal-fired generating units.[51] Table IV.A.1 shows that in 2007, West Virginia coal-fired generation emitted 85.6 Mt of CO_2eq. West Virginia could choose to meet upcoming GHG reduction goals by simply backing off generation. As the state is a net exporter of electrical power this could be done without reducing in-state electrical power usage. However, before choosing this option the state would want to further examine the economic impact of such an action. As stated previously in this report, CCS could provide a method whereby existing coal-fired generation could continue at the same or even increased levels.

From a national perspective, as of 2005 there were approximately 1470 coal-fired generating units in the United States representing 313,380 MW of capacity.[52] A simple proportional reduction could mean that 53,275 MW of this total would have to achieve 100% reduction in CO_2 emissions by 2020 to meet the 17% reduction goal listed in ACES. While there may be other methods of achieving compliance with the requirements outlined in ACES,[53] at some point a significant portion of the 313,380 MW of coal-fired power will either have to be retrofitted with CCS or retired. In addition, as shown in Table IV.A.1, there is considerable coal-fired generation worldwide, In many countries, especially in developing nations, the often readily available coal may still be the most economic option for these countries to provide the standard of living that they have not yet been able to achieve. It is possible that many of these nations will choose to continue to build new coal-fired generation and will not have the ability to develop low carbon technology to do so. CCS technology, developed in West Virginia and other US states, could be shared with some of these nations in a manner designed to lower world-wide emissions.

It may not be possible to say that the development of CCS in West Virginia is absolutely essential. However, the challenges discussed above demonstrate that CCS could be an integral part of achieving the goal of greenhouse gas reduction pending a satisfactory resolution of issues such as those listed in questions 2 through 4 above.

When will a need for CCS become a reality?

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[51] USDOE EIA. Generating Units - http://www.eia.doe.gov/cneaf/electricity/page/capacity/existingunits2005.xls
Total MW - http://www.eia.doe.gov/cneaf/electricity/st_profiles/sept04wv.xls

[52] USDOE EIA. Electric Power Industry 2008: Year in Review, Table 1.1. Existing Net Summer Capacity by Energy Source and Producer Type, 1997 through 2008 http://www.eia.doe.gov/cneaf/electricity/epa/epaxlfile1_1.pdf

[53] For instance carbon offsets, energy efficiency measures, energy conservation practices and repowering with lower or zero carbon emitting resources.

There are a number of unknowns in answering this type of question. The first is the prospect for the establishment of binding legislative or regulatory action mandating some form of reduction in greenhouse gas emissions. The second is the actual form that such reduction requirements will take and what other methods may be allowed to enable emitting sources to develop technical and administrative processes needed to achieve reductions.

Regarding legally binding requirements, ACES has now been joined by the American Power Act (also called the Kerry – Lieberman bill) which is the Senate version of ACES. There are many similarities between the bills, both of which follow a cap and trade program for greenhouse gases. There are many different projections regarding the possible approval of the bill in the US Senate, but should it pass, there would need to be a conference version agreed to by both houses. The timing of such a consensus between the two houses is unknown at this time.

The USEPA, on May 14, 2010, released its "Tailoring Rule" which sets a roadmap of how the Agency will handle air quality permitting for stationary sources of greenhouse gases in the wake of its endangerment declaration. This declaration, issued on December 7, 2009, states that the emission of greenhouse gases in the United States constitutes an endangerment to public health and welfare. As of January 2, 2011, power plants (and other sources) emitting greenhouse gases will have to consider these emissions in any decisions made regarding their impacts on air quality.

There are currently conflicts between the programs that would be set up under the congressional action and those established under the USEPA actions, but under either approach the emissions of greenhouse gases, including $CO_{2,}$ will be controlled to some extent in the near future.

The actual form of whatever regulatory or legislative requirements are chosen for GHG emission control will have a very large impact on the timing the need for CCS. For example, in the proposed ACES there is an allowance for a phase-in for CO_2 reduction from coal-fired power plants as such sources could use emission offsets in the early years. In such a case the need for CCS could be postponed until the post-2020 period.

However, if reductions are called for too early or are too stringent to be compatible with the technical, administrative and economic demands of CCS, coal-fired generation may be precluded from using CCS. Utility generators may then be forced into investment in lower carbon natural gas generation (with a CO_2 emission approximately ½ of that emitted by coal) in the years before CCS is ready.[54] In this situation, a market for coal-fired CCS may never exist. A need to shift to natural gas generation in the next ten years could also tend to lock in generators to using gas for a period long enough to allow the recovery of the cost associated with the investment. Natural Gas CCS is, of course, an option although the technology is currently not being developed. In determining whether CCS is indeed in the best interest of the state, the Legislature may have to decide whether coal or natural gas generation of electrical power allows the best future for the State of West Virginia.

[54] For example, Calpine Corporation in a presentation discussing its new Russell City Energy Center cited its proposed permit limit for CO_2 of 1100 lbs/MWh but referenced reports of NGCC plants achieving results of 800 lbs/MWh. A coal plant, usually emitting 2000 lbs/MWh, would emit <800lbs/MWh with a removal efficiency of 60%. Calpine Corporation. GHG BACT Analysis Case Study. Presentation to EPA Climate Change Work Group, November 19, 2009 (as updated February 3, 2010). Slides 8-9. http://www.epa.gov/air/caaac/climate/2010_02_GHGBACTCalpine.pdf (Accessed February 10, 2010)

Such a situation could be encountered in some legislative actions or if the USEPA must proceed with regulatory controls under existing Clean Air Act requirements. If the USEPA carries through with its proposed regulation of CO_2 some have argued that the Agency could have to set limits in a manner that may force utilities into programs that would take effect in ways the Agency may not have considered.[55] If the USEPA must develop restrictions that impose large reductions before CCS is commercially available this may cause CCS to become less attractive and accelerate any move away from coal as a power source.

The best atmosphere for the use of CCS and for the continued ability of the nation to be able to use coal as an energy source would be one in which significant reductions in CO_2 emissions would not be required until the demands noted above have time to be resolved. Estimates of when CCS will become commercially available (i.e., technically developed and economically feasible) vary depending on who is making the projection. In general, it is anticipated that this is most likely to happen in the 2020 -2030 time period.[56]

What is currently available to meet such a need?

There are currently a number of technologies that are being considered for providing efficient, commercially available CCS at the lowest possible cost. Any currently considered methods (none of which are commercially available) tend to be energy intensive and thus very expensive. Some proposed methods of carbon capture would require a different form of boiler technology while others would involve extensive boiler retrofit.

However, it should be noted that various businesses operating in West Virginia are already taking a leading role in investigating and developing CCS.

- The AEP/APCo Mountaineer Plant CCS Process Validation Project is the first project in the world in which an actual 20 MW slipstream from the emissions of a coal fired power plant is subjected to a carbon dioxide capture process with the captured material sequestered in a geological strata approximately 8000 feet below surface grade at the plant. The project began actively operating on October 1, 2009, and successfully captured and sequestered CO_2 until May 2011. The capture technology being demonstrated in this project is the chilled ammonia process developed by Alstom, an international company that designs, manufactures and supplies products and systems for power generation.
- AEP and APCo are also performing the preliminary work on developing the first commercial scale CCS project in coordination with a grant from USDOE. The 235 MW project will also capture and sequester carbon dioxide

[55]See, for instance, Greenhouse Gas Regulation under the Clean Air Act Does Chevron *Set the EPA Free?* December 2009 Resources For the Future. Available at:
http://www.rff.org/Publications/Pages/PublicationDetails.aspx?PublicationID=20964

[56] See for instance "Facts and Trends: Carbon Capture and Storage (CCS)" World Business Council on Sustainable Development, October 2006 which in 2006 predicted a 20 year time frame or "Future of Coal," Testimony before the Committee on Energy and Natural Resources, United States Senate by Bryan Hannegan, Vice President, Environment, Electric Power Research Institute, March 22, 2007 who stated that to achieve the goals being discussed in upcoming legislative efforts all new plants would need CCS after 2020.

from a portion of the emissions from the Mountaineer 1300 MW generating unit using the Alstom chilled ammonia process.

The project is being undertaken in conjunction with a diverse technical advisory committee that includes recognized experts in the field of geologic carbon dioxide storage. This group will include participants from Schlumberger Limited, Battelle, Lawrence Livermore National Laboratory, Massachusetts Institute of Technology, The Ohio State University, West Virginia University, The University of Texas, West Virginia Geological Survey, Ohio Geological Survey, CONSOL Energy and the West Virginia Department of Commerce Division of Energy. Additionally, Battelle and Schlumberger will work directly with AEP to design and deploy the carbon dioxide storage system.

- Alstom and Dow CO_2 Capture Pilot Plant - On September 10, 2009, The Dow Chemical Company (Dow) and Alstom dedicated a carbon dioxide (CO_2) capture pilot plant at the South Charleston facility. In 2008, the two companies entered into a Joint Development Agreement to develop this technology, and in March 2009 announced plans to design and construct the pilot plant.

- This pilot plant will capture CO_2 from the flue gas of a coal-fired boiler at the South Charleston plant. The pilot plant will use proprietary advanced-amine technology to capture approximately 1,800 metric tons of CO_2 per year. The pilot plant will operate for two years, generating and collecting data that can be used to optimize and implement this technology at coal-fired power plants worldwide. This new process will significantly reduce the amount of energy required for CO_2 separation and capture.

  The Alstom pilot plant is running well. The process is on-line daily, recovering CO_2 from the Dow coal-fired boiler flue gas. Data from the plant is being used for R&D purposes and process information for future pilot scale and full-scale carbon capture projects throughout the world. Tests include long-term chemical degradation, carbon capture efficiency, energy efficiency, analytical methods, operating procedures and control strategies. Current test plans project operation into 2011.[57]

- CONSOL Energy, with partial funding from the U.S. Department of Energy and in collaboration with West Virginia University, began injecting CO_2 into an "unmineable" coal seam in Marshall County, West Virginia, in September 2009 to simultaneously sequester the CO_2 and to enhance the production of coalbed methane. The WVDEP issued a Class II Underground Injection Control permit for the project. The team expects to inject up to 20,000 tons of CO_2 over the course of two or more years and to continue to monitor the site for up to two additional years.[58]

Are there alternatives to CCS for meeting those needs?

[57] Amos, J. , Dow Environmental Manager – Personal communication, June 1, 2010.
[58] Winschel, R. A., Director of Research Services, CONSOL Energy, Inc. Personal Communication, June 7, 2010.

Using ACES as a surrogate for predicting future reduction requirements and the 2005 base emission rate from West Virginia sources of 84.1 Mt, electric generation sources in West Virginia would have to reduce emissions to 83 Mt CO_2eq in 2012, 71 Mt by 2020, 50 Mt by 2030 and 15 Mt by 2050.[59] Such reductions in emissions cannot be achieved without either a technology to remove and permanently store CO_2 from power plant emissions or a significant reduction in coal use for electric generation.

Natural Gas

One suggestion, a large shift to natural gas generation, would perhaps postpone the need to capture and store CO_2 but as stated above natural gas still emits roughly one half the CO_2 that results from coal-fired generation. Emission reductions outlined in either ACES or the American Power Act would require further controls in the post 2020 period.

Nuclear Power

More reliance on nuclear power could be an alternative to CCS. Nuclear power is widely used in Europe and throughout the U.S. Despite fears about its safety, it has the best safety record of any fuel for electric generation. There are currently 26 applications for nuclear power plants in the US pending before the NRC.[60] West Virginia, however, has not pursued such options in the past. Conceivably, this is an option that the state could pursue. However, if this course were to be pursued, the Legislature may have to revisit the apparent barrier to the employment of nuclear power in articles §16-27A-1 and §16-27A-2 of the state code, which require that a nuclear power plant must be economically feasible and that a permanent national repository for nuclear waste disposal has been proven safe and functional.

Hydro Generation

West Virginia does have access to significant water resources, a factor that has contributed to the ability of the state to utilize its coal supplies to export electrical power. Hydropower could be further developed in the state. West Virginia has areas with significant elevation change across the state that could allow the exploitation of the stored energy located in upland areas. While the construction of dams for energy generation is not favorably considered under current public sentiment, in an era of changing energy options and increasing CO_2 concerns, the state may be able to further investigate hydropower. In addition, small scale hydro which does not involve building dams is a promising use of West Virginia's water resources.

Wind

Wind power is becoming an important state resource. West Virginia is already one of the leading states for commercial wind development in the eastern U.S. and other sites are under construction and in the planning stage. As of the date of this report, West Virginia has 431 MW of wind capacity producing commercial electrical power.[61] This makes West Virginia the state with the 56th largest installed capacity east of the Mississippi River.[62] Wind power may be

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[59] Based on % reductions listed in ACES Title VII section 702 and base 2005 emission from all generating sources of 85,649,741mmt from US Energy Information Agency, State Historical Emissions Tables for 2008, line 21929. http://www.eia.doe.gov/cneaf/electricity/epa/emission_state.xls retrieved January 22, 2010.
[60] Deutch, J et. al. *Update of the MIT 2003 future of Nuclear Power,* Massachusetts Institute of Technology, Cambridge MA
[61] U.S. Department of Energy, Wind Powering America.
[62] Ibid.

becoming more difficult to build as public opposition is often seen to utility scale plants. Major wind resources in West Virginia appear to be located on the eastern ridge lines, an area that many feel needs to be protected. Utilization of commercial wind development is also extremely reliant on the availability of adequate transmission capacity. West Virginia may not have sufficient wind capacity to ever become self-sufficient in electrical production using wind alone, but appropriate utilization of the state's wind resource could be an important aspect of a diversified energy portfolio.

Nationally, wind energy's ability to offset carbon emissions depends on power system operations and the ability to anticipate its output. Because wind is intermittent it cannot be dispatched as regularly as fossil-fired power generation. Combined with flexible generating technology within a responsive real-time system, wind power can be efficiently integrated. But due to its intermittency wind will never be a major component of the power system and the challenges of integration may increase with greater amounts of wind capacity.

Biomass

Biomass co-firing and wood-fired power generation are two other sources of base-load electricity that could be produced in West Virginia. Based on physical quantities, wood residue available in the State could support several power plants of up to about 50 MW. However, the variability of transport costs due to the fuel's locations relative to a plant site could restrict plant size. A single such 50 MW plant operating at an 80 to 90 percent capacity factor would provide less than half a percent of electricity currently generated in the State. The relative capital cost of such a plant is competitive and production tax credits could apply depending on how associated forestry management contributes to carbon levels.

Biomass produced to be co-fired with coal could play a larger role but is not widely developed. Switchgrass or some other energy crop, as well as wood residue, can be compressed into bricks or pellets that on a ton-per-ton basis contain an energy value comparable to Powder River Basin coal.[63] Trial switchgrass crops on former surface-mined lands in West Virginia are presently being evaluated for yield. Generally, pilot scale tests co-firing no more than 20% biomass with 80% coal have been assessed.[64] Overall, biomass represents a modest and underutilized energy resource that if it became available could theoretically, employing the mix cited in these pilot studies supply up to 20 percent of energy inputs for base-load power generation. This would, of course, depend heavily on the supply of low cost biomass within an economically viable distance from the power plant.

Solar

It is sometimes assumed that West Virginia has limited potential for solar electricity due to low insolation. However, Germany, whose population is about 50 times that of West Virginia, currently obtains about one percent of its electricity from solar. Insolation should be greater in West Virginia than in Germany, since our state lies roughly 12 degrees further south. Much of Germany's solar capacity has been installed since its Feed-In Tariff (FIT) law was restructured in 2000. Additional incentives for solar installation could be considered in West Virginia.[65]

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[63] Presentation by Mid-West Biofuels on October 28, 2009.
[64] http://www.eesi.org/files/cofiring_factsheet_030409.pdf
[65] http://www.worldwatch.org/node/5449#notes

It should be noted that the city of Nitro has received monies from the the USEPA to conduct, in partnership with the West Virginia Brownfields Assistance Center, "a one year study to collect critical solar data to evaluate the potential for solar power development at the commercial, community and local business scale by using some of the over 800 acres of former industrial properties. Data collected will be compared to existing NREL (Department of Energy's National Renewable Energy Lab) information on solar generation potential, as well as provide valuable clean energy information for the Nitro community and surrounding areas."[66]

Energy Efficiency

In its *2009 State Energy Efficiency Scorecard*[67], the American Council for an Energy Efficient Economy ranked West Virginia at 45 and included it among the states that "most need to improve." Based on studies of this type some may conclude that enhanced energy efficiency programs would dramatically reduce the need for CCS retrofits, would be less expensive, and would involve none of the environmental and legal issues associated with CCS. Discussions regarding energy efficiency will continue in the Feasibility Subcommittee.

Maryland and Ohio both mandate that utilities have plans to reduce consumer demand by 15 % by 2015. Through energy efficiency programs, West Virginia could meet a significant portion of its greenhouse gas reduction requirements and save money for consumers in the process. According to the American Council for an Energy Efficient Economy, implementation of the energy efficiency provisions in the ACES Act could result in creation of 2700 jobs annually in West Virginia, save consumers $521/year (2007 $/household), and lower CO_2 emissions by 6 Mt.[68] An energy efficiency bill has been introduced in the West Virginia legislature in 2009 and 2010 (HB 4012 for 2010). In the 2009 session, the West Virginia Legislature recognized the importance of energy efficiency measures by including "*energy efficiency technologies"* as methods to be used for compliance with the state's goals as established in the West Virginia Alternative and Renewable Energy Portfolio Standard Act.

CO_2 Transport

Another potential alternative to CCS would involve the participation by West Virginia in some of the various projects currently being proposed involving the transport of captured CO_2 to places where it may be considered to be a valuable commodity. CO_2 can be effectively utilized and potentially geologically stored in enhanced oil and gas recovery operations. There are many areas of the United States with recoverable oil and gas reserves that can not be economically produced with other methods. Many of these reserves still possess significant reserves but are not being worked due to a lack of useable CO_2.

In addition, almost any commercial scale CCS project would require multiple injection sites, some of which may be located at areas some distance from the point of generation of the CO_2. This could involve the construction of intrastate and potentially even interstate pipelines. There are technical, legal, administrative and public safety issues involved that West Virginia may need to address.

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[66] http://www.epa.gov/reg3hscd/bf-lr/newsletter/2009-Fall/repower.html

[67] http://aceee.org/pubs/e097.pdf?CFID=1338466&CFTOKEN=56457960

[68] Gold, R., L. Furrey, S. Nadel, J. Laitner, and R. N. Elliott, 2009. Energy Efficiency in the American Clean Energy and Security Act of 2009: Impacts of Current Provisions and Opportunities to Enhance the Legislation. American Council for an Energy-Efficient Economy, Report E096.

What are the projected costs to West Virginia?

In any assessment of the cost of deploying CCS in the state there are a number of areas that must be addressed to answer the question. First, is the actual economic cost of installing and operating CCS feasible for facilities operating in the state. Second, what impact would the installation of such technology have on the overall economy of West Virginia? And third, what are the potential impacts on the safety and health of the people of West Virginia and the overall environmental integrity of the state. These areas are addressed in the next two sections of this report.

Question 1: What factors need to be considered in determining if CCS is feasible and beneficial for West Virginia?

IV.A.4. Cost Comparisons of Various Technologies

How expensive is the installation of possible technologies expected to be and is such an expenditure in the best interest of the state? A literature-based study was performed in an attempt to estimate some of the cost associated with constructing and operating a CCS facility and how these costs may compare with other low-carbon alternatives.

It should be noted that the costs included in this section should be considered as a comparison type analysis and should be viewed as representing the result of a specific set of assumptions which may vary over time. The subcommittee would like to caution those reading this report that even comparative rankings listed herein may change as conditions evolve. As discussed earlier CCS may not be the least expensive of a number of different means of achieving some of the goals associated with a desire to reduce carbon dioxide emissions. The Feasibility Subcommittee will continue to evaluate the need for CCS to be part of the State's efforts to achieve these goals. The Legislature will have to decide which of the proposed means of achieving these goals are in the best interest of the citizens of West Virginia.

Cost of Various Technologies

The purpose of this study was to determine the economic feasibility of Carbon Capture and Sequestration (CCS) for fossil fuel electric generation in the State of West Virginia as compared with alternative electric generating technologies. We have reviewed publicly available documents for the costs of electric generating technologies and CCS technologies. The cost data vary widely as there is little operating history of CCS costs. The published CCS information that is readily available consists of projected costs based upon data from operating generation plants, and information learned generally from experimentation and demonstration CCS projects.

The widely accepted method of evaluating the economic feasibility of an electric generation technology is to determine the Levelized Cost of Electricity (LCOE) produced. The levelized cost considers all of the components of cost including permitting, financing and capital cost, as well as the components that make up a plants fixed and variable operating costs levelized over the life of the facility. A number of studies are available which examine the capital and levelized costs of a variety of electric generating technologies. Data was selected from the Energy Information Administration Annual Energy Outlook 2009 and three studies prepared under the auspices of the DOE/NETL. The first DOE study *"Cost and Performance Baseline for Fossil Energy Plants DOE/NETL 2007/1281 Volume I Bituminous Coal and Natural Gas to Electricity"* Rev1 examined the cost of new electric generating facilities. The second DOE study: *"Carbon Dioxide Capture from Existing Coal Fired Power Plants DOE/NETL-401/110907"* examines the cost associated with adding CCS to existing facilities. The third study: *"CO_2 Capture Ready Coal Power Plants DOE/NETL 2007/1301 Final Report April 2008"* examined the cost effectiveness of including in the original design of a coal-fired power plant the capability to retrofit a CCS system.

The competing energy forms were compared on a levelized cost of electricity basis to determine relative cost competitiveness. The results of the effort in executive summary format are contained herein.

As noted above, the data varied widely. The final projected costs in this report are not to be construed as projected costs of production on an individual generating site basis. The inputs for O&M can vary widely for each source depending on geographic location, fuel supply costs, etc. A true cost analysis would need to be performed on a case by case basis taking into consideration additional variables such as local legislation, demand for base load vs. peaking power needs, capacity factors of the various generating forms to meet demand, infrastructure needs, etc. The reported costs should be used to generally compare competing technologies to determine whether CCS is in the realm of competitiveness, and therefore whether the State of West Virginia should even consider legislation to promote its use.

The capital costs as published in the studies are provided in Table A.1 for plants without and with CCS. The reported capital costs are listed to show the relative size of initial investment needed for the competing technologies, however, many of the figures are dated, and actual current capital costs are likely significantly higher.

In Table IV.A.1, the IGCC with CCS $/kW cost is listed at $3496/kW. A company is planning to build a $1.75 billion coal gasification power in Ector County, Texas. Summit Power Group's Texas Clean Energy Project calls for it to be a 400-megawatt net (560 MW gross) integrated combined cycle (IGCC) plant that is designed to capture 90 percent of the carbon dioxide produced. According to a news release, the plant will capture 3 million tons of CO_2 annually, which will be used for enhanced oil recovery in the Permian Basin. Using the numbers being proposed by Summit Power as current estimates for IGCC Construction (hard costs) with 90% CO_2 capture, the data would translate to approximately $3125/kW (gross) or $4375/kW (net).

Another proposed IGCC facility in Mississippi is expected to be in service in 2013 has a total system cost of $3000/kW with 50% carbon capture. This information is from Southern Company's public comments.

The costs of a nuclear power facility as stated in the EIA report appear to be much lower that the current estimates by utilities and others which are in excess of $6000/kW.[69] Ontario Hydro recently announced canceling a large Nuclear power plant project as the capital costs have now exceeded $10,000/kW. The capital cost estimate shown in Table IV.A.1 is approximately 50% of the current low end estimate of the cost of an advanced nuclear plant currently under consideration.

The reported capital costs for adding CCS to an existing PC coal plant include the initial capital for constructing the plants, and therefore are overstated.

[69] Federal Energy Regulatory Commission Increase Costs in Energy Markets (Staff Report) June 9, 2008.

Cost figures in Table IV.A.1 do not include the offsite capital costs of power transmission or infrastructure, which could be substantial particularly for wind and solar since the generating capacity per power unit is very small and substantial expansion of the current transmission would be required for infrastructure to accommodate many smaller generating units. The capital costs for infrastructure requirements of solar powered generation could be negated to a degree with alternative roof top installations.

TABLE IV.A.2
Capital Cost $/kW

Capital Cost				
			EIA Study 2007$	
			Note 2	
Natural Gas Combined Cycle (NGCC)			948	
NGCC with CCS			1890	
Wind			1923	
New Pulverized Coal (PC)			2058	
Integrated Gasifier Combined Cycle (IGCC)			2378	
Nuclear			3318	
IGCC with CCS			3496	
Biomass			3766	
New PC with CCS		Note 3	3846	
Solar			5021	
Existing PC with retrofit CCS		Note 4	5050	
Notes:				
1) Source: US Energy Information Administration Annual Energy Outlook 2009 except as otherwise noted. Cap Ex costs taken from EIA Annual Energy Outlook 2009 Assumption to the Annual Energy Outlook 2009 Table 8.2 Cost and Performance Characteristics of New Central Station Electricity Generating Technologies				
2) Overnight capital costs including contingency factors, excluding regional multipliers and learning effects. Interest charges are also excluded. These costs represent new projects initiated in 2008 expressed in $2007. Capital costs are shown before investment tax credits are applied where applicable				
3) The capital cost of a PC unit with CCS was not included in the EIA study. The data provided in the Cost and Performance Baseline for Fossil Energy Plants DOE/NETL 2007/1284 Volume I Bituminous Coal and Natural Gas to Electricity Rev 1 August 2007 was used to determine the incremental cost of adding a CCS to a PC unit as a percentage of the capital cost of a PC unit without CCS. That percentage was applied to the capital costs of a PC unit as defined in the EIA study to estimate the cost of a PC unit with CCS.				
4) The capital cost of retrofitting a PC unit with CCS was not included in the EIA study. The data provided in the CO_2 Capture Ready Coal Power Plants DOE/NETL 2007/1301 Final Report April 2008 was used to determine the incremental cost of adding a CCS to an existing PC unit as a percentage of the capital cost of a new PC unit without CCS. That percentage was applied to the capital costs of a new PC unit as defined in the EIA study to estimate the cost of an existing PC unit with CCS. The total cost is conservatively high as the retrofitted PC unit would have a depreciated value with respect to the capital cost of a new PC unit and thus the total capital cost would be less than the cost of a new PC unit and a retrofitted CCS as stated herein.				

TABLE IV.A.3
Ranking of Levelized Costs $/MWh

	EIA Study 2007$					
	w/o CCS	Rank		w CCS	Rank	Notes
Nuclear	107.3	4		107.3	1	
Biomass	107.4	5		107.4	2	
IGCC with CCS at DOE Target Price	N/A			113.9	3	4
NGCC	79.9	1		115.7	4	
IGCC	103.5	3		122.6	5	
New PC with CCS at DOE Target Price	N/A			127.7	6	3
Wind	141.5	6		141.5	7	
New PC	94.6	2		175.6	8	
Existing PC Retrofitted w CCS	N/A			201.2	9	2
Solar	263.7	7		263.7	10	
Notes:						
1) Overnight capital costs including contingency factors, excluding regional multipliers and learning effects. Interest charges are also excluded. There costs represent new projects initiated in 2008 expressed in $2007. Capital costs are shown before investment tax credits are applied where applicable						
2) The levelized cost of energy (LCOE) of retrofitting a PC unit with CCS was not included in the EIA study. The increase in LCOE as a result of retrofitting a CCS was defined in Carbon Dioxide Capture from Existing Coal-Fired Power Plants DOE/NETL-401/110907 (Final Report Original Issue Date, December, 2006 Revision Issue Date November, 2007). The percent increase over the base case (no CCS) was applied to the base case LCOE of a PC unit as defined in the EIA study to determine the incremental LCOE to retrofit CCS to an existing PC unit. The LCOE of a retrofitted PC unit as stated here is conservatively high as the retrofitted PC unit would have a depreciated value with respect to the capital costs of a new PC unit and thus the LCOE would be less than the cost of a new PC unit with a retrofitted CCS as stated herein.						
3) DOE's goals for CO_2 capture in combustion systems as stated in DOE document: Existing Plants, Emission and Capture - Setting CO_2 Program Goals, dated April 20,2009 (DOE/NETL-2009/1366) are to limit the maximum increase in LCOE to 35%. This value was used to determine the LCOE in the table above.						
4) DOE's goal for CO2 capture in gasifier systems is to limit the maximum increase in LCOE to 10%. This value was used to determine the LCOE in the table above.						

Table IV.A.3 presents the levelized costs of the various technologies. In the EIA data, for cases without CCS, NGCC is the low cost alternative followed by pulverized coal, IGCC, nuclear, biomass, and wind. Specific site factors and other factors would weigh into the selection of a specific technology for a selected site. Solar appears to be higher than the other technologies.

When CCS is included, fossil fuel technologies would incur an incremental increase in LCOE due to the capital and operating costs of the CCS. Table IV.A.3 includes the EIA estimates of the LCOE based on current CCS technology development. However, DOE has established goals of advancing technology such that the incorporation of CCS in a gasification process or in a combustion process will not increase the LCOE by more that 10% and 35% respectively. Therefore estimated LCOE's for those technologies were also provided which reflected the achievement of the DOE goals.

In the study, the ranking of nuclear improves with the requirement for CCS. The results indicate that nuclear provides a low LCOE. However, the capital and operating costs of the advanced nuclear design are the least known among all of the technologies and as stated earlier, the capital cost estimate shown in Table A.1 is approximately 50% of the current low end estimate of the cost of an advanced nuclear plant currently under consideration.

Biomass provides a low LCOE when CCS is a requirement. This is due to the fact that biomass would not be required to install CCS systems. Biomass is followed in succession by IGCC achieving DOE cost goals, NGCC with CCS, IGCC with current pricing, PC achieving DOE cost goals and wind. The cases of a new PC with current CCS cost estimates and an existing PC with retrofit CSS cost estimates follows with the solar option resulting in the highest LCOE.

On a levelized basis, with CCS included, the ranking of some of the renewable technologies improves (nuclear and biomass). The fossil fuel technologies remain economically viable when compared to the other renewable technologies particularly if the DOE costs goals are at least partially achieved.

The data compilation suggests that CCS technologies should continue to be pursued to provide not only a viable means to capture and store carbon, but also to retain the competitiveness of the fossil fuels we are abundantly blessed with in West Virginia. The actual supply of electricity in a region will be a makeup of several sources of supply based upon the actual LCOE of each source, and its capacity for base load supply.

Study Scope: Estimating the Economic Impact of Implementing CCS in West Virginia

Second, in our consideration of the costs of CCS, what must we know before we can estimate the impact that such a program would have on the economy of West Virginia? An additional study looked at what would need to be done to address this question.

Implementing carbon capture and sequestration (CCS) will require Federal mandates and/or financial incentives. West Virginia-based emitters will not undertake the expenses associated with CCS without being required to do so or being faced with a more expensive alternative to reduce CO_2 emissions such as cap-and-trade or carbon taxes. Because it participates in regional markets for electricity and coal, West Virginia will not implement CCS on its own due to competition. An analysis of the impact of CCS in West Virginia is highly linked with the impacts of doing so in most of the Eastern U.S.

CCS is a capital-intensive activity and most emitters have little experience with it. While the use of CO_2 injection in the oil and natural gas industry is a highly developed technology, that experience is only partially transferable to emissions from electric generators using coal. To fully implement CCS will take many years, and the nature of capture will change as the technology used by emitters changes.

The economic impact of CCS in West Virginia depends much on the timeframe desired to be evaluated. The need for new fossil-powered electricity generation capacity will depend on growth in demand. In the next 20 years, much new generating capacity will be built to meet state renewable portfolio standards, which emphasize the use of alternative and renewable fuels. Under the West Virginia Alternative and Renewable Energy Portfolio Standard, electricity generated from coal with CCS counts; however, this is not the case in other states. Energy efficiency measures could also suppress demand growth. Thus, it is likely that most carbon will initially be captured with equipment added onto existing units. However, in 20 to 40 years a different type of generating capacity may be needed and new fossil units may be built with capture technology. As with all forecasting analyses, the longer the time-frame of evaluation the more assumptions will need to be made about demand and technology.

Pending Legislation

Recent efforts towards carbon regulation have generally focused on either carbon taxation or cap and trade. CCS is a stand-alone alternative if mandated or would be incentivized with a sufficiently large tax or very low cap on carbon emissions. If an imposed tax or the cost of emission permits under cap-and trade in terms of costs per ton of emitted carbon is greater than the cost of CCS, then affected industries may elect to do CCS depending on the relative costs of other technologies.

Based on historical experience it is reasonable to assume that the costs of CCS technology will fall dramatically as implementation and research continue. The pace of this progress is difficult to predict and becomes more uncertain the longer the time frame used for evaluation. Any public policy which makes coal less competitive will provide an additional incentive for private research, but much of that research will require subsidization. For good reason firms are reluctant to make major financial commitments to newer technologies. Often the cost is high, the technology unproven and the certainty that even newer technologies with lower costs and increased efficiencies will emerge, makes the commitment of private capital less likely at the outset of CCS implementation.

Depending on market forces, the regulatory environment and the pace of introduction of alternative fuels, it may be possible for coal generators to pass the costs of CCS on to the consumers of electricity. Evaluating the ability of electric generators to do this would have to be part of any impact analysis. Incurring the costs of CCS in West Virginia could be better economically for the State than for its utilities to simply pass along the cost of the tax or to participate in cap-and-trade, because a new industry will develop around CCS and with it jobs and expertise. The trade-off between the creation of a new CCS industry and the possibility of forward shifting of the CCS cost would also need investigation.

Scale of Implementation

There are 14 or 15 coal-fired power plants in West Virginia that would currently be affected by carbon legislation. Carbon dioxide emissions from these plants amount to a little more than 86 million metric tons, about 3.4% of national levels from the electric power industry. It is likely that one or two of these plants would be retired if carbon capture were to be mandated. This would be determined by the costs of retrofitting older plants. If cap-and-trade is used these plants would be eligible for carbon emission credits. Closing them and using the credits to offset emissions elsewhere could prove to be a viable business strategy. A handful of industrial direct coal users would also be affected. In any analysis of the future of generation in West Virginia some assumptions would need to be made about which plants might be subject to closure.

Current Projects

West Virginia is the site of several projects developing CCS Technology. A short description of these projects is found on pages 26-27. Because of these pilot projects, West Virginia is now a leader in deployment of CCS. If CCS becomes widespread the State will benefit from this experience. These pilot projects, in West Virginia and elsewhere provide valuable information but they are only the first of several steps in proving the feasibility of CCS.

Categories of Impact

There will be both positive impacts from spending and negative impacts from increased costs due to implementation of CCS. The primary costs of CCS will be borne by coal-fired power plants. Primary Impacts:

Higher electricity prices for residential, industrial and commercial consumers

The estimated costs of CCS vary by type of generator. Capture can take place pre or post-combustion, with pre-combustion costs appearing more costly at present compared to adding technology to existing steam units. Older estimations have been as low as around $36/tonne (IPCC in 2002) but more recent figures are closer to $90 for CCS post-combustion. In 2007, MIT estimated that a carbon price of $30/tonne would make CCS cost competitive. In West Virginia rates could more than double, with residential rates expected around 18 to 19 cents per kWh.[70]

Because West Virginia's electricity mix is 98 percent coal and other states in the region have lower coal shares, the price impact will be higher in West Virginia than in other states. The indirect effects will include reducing any competitive advantage that exists for manufacturing inputs and to disproportionately reduce disposal income for households. Correlated federal incentives to induce energy efficiency investment for all sectors and to reimburse low-income households will offset some of the negative impacts and could cause some manufacturers to remain in West Virginia rather than moving to areas where products costs are lower.

Reduced and less competitive electricity exports

West Virginia is among the largest exporters of coal-fired electricity. Based on its overall generation mix, West Virginia exported nearly 36 million MWh of coal-fired electricity in 2009, more even than Pennsylvania the largest state-level exporter of electricity and more than Texas, the largest state-level producer of coal-fired electricity. .[71] Electricity exports contribute to low electricity prices for WV customers. While it is expected that coal-fired power generation in WV will need to be maintained at near current levels for at least 20 years, the long-term generation mix could be significantly different. Carbon capture at a power plant also requires diverting a portion of the plant's output to that capture, thus reducing the amount of electricity that can be delivered to customers.

Changed sourcing of coal for power generation

The cost of carbon capture could change the origin of coal supply as some regional power plants may choose to substitute cheaper, low-Btu or other coal for West Virginia coal. Sub-

[70] Presentation by Mark Dempsey of Appalachian Power at the "Energy and Natural Resources Symposium" on October 29, 2009. It is uncertain what technology cost assumptions are incorporated within these figures.
[71] US DOE, EIA. 2009 State Electricity Profiles.

bituminous coal from Wyoming's Powder River Basin can be brought to West Virginia at competitive prices and WV power plants with new pollution control technologies can purchase cheaper coal from areas like the Illinois Basin. On the other hand, IGCC technology is not compatible with PRB coal which greatly reduces the fuel options for that type of plant.

Creation of a new industry with uncertain cost and indirect effects

Industries that buy carbon byproducts can be indirectly impacted by the industry. Capture costs can be offset when there is a market for chemical byproducts resulting from the separation of carbon. For example, when CCS is linked to enhanced oil and gas recovery, the economies improve. The most similar existing industry to a CO_2 transport and storage industry is probably drilling oil and gas wells. Studies estimate the cost of transport and storage of CO_2 at around $15 per ton.[72]

Transportation costs

One critic of CCS has contended that the transportation of CCS must be included in any feasibility considerations[73]. While most attention has focused on capital and storage costs the expense of moving the amount of carbon from the place of generation to the site of storage is formidable. While stating the CCS is inefficient as it consumes electricity to capture emissions requiring the burning of 25 percent more coals to gain the same amount of electric output. The critic states:

> The harder challenge would be transporting and burying all of this high-pressure CO_2 Collectively, America's coal fired power plants generate 1.5 billion tons per year. Capturing that would mean filling 30 million barrels with liquid CO_2 every single day—about one and ha half times the volume of crude oil the country consumes. It took roughly a century to build the infrastructure we use to distribute petroleum products[74].

The author feels neither the engineering or financial issues concerning building those extensive networks have been contemplated much less started.

While this may be seen as an extreme calculation as CCS will be implemented over a period of time, the need for including the cost of this infrastructure cannot be ignored in feasibility calculations. In West Virginia CCS will require both intra-state transport connections which must coincide with interstate ones. Determination of these expenses should be added to the feasibility determination.

Dynamic Modeling

Estimation of the economic impact of CCS on the West Virginia economy must be modeled dynamically to capture net impacts and because it will only be accomplished over several years. Assumptions regarding the phasing of implementation, the number of years to full implementation and the percent of carbon captured each year in the interim are important

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[72] J. J. Dooley,R. T. Dahowski, C. L. Davidson, "*On The Long-Term Average Cost of CO2 Transport and Storage,"* U.S. Department of Energy, Washington, DC, March 2008 http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17389.pdf

[73] Meigs, J.B. (Feb. 2010) "The Myth of Clean Coal" Popular Mechanics, 50-51

[74] Ibid. 52

variables. In the next 20 years, the impact will be seen largely as retrofits to existing fossil units, while in the following 20 years new fossil and/or nuclear units will be built. The phasing of implementation can also be influenced by the availability and costs of alternative fuels.

The net effect of higher generation cost and less generation will depend on the timing of CCS implementation, demand response and other electricity suppliers. Quantification will require development of a credible set of assumptions to simulate consumer and industrial response.

There is also a question of a long-term health impact from reducing carbon emissions. Will West Virginia see a direct or indirect positive impact to reducing emissions or will the benefits be felt more in coastal areas? Research should be done to evaluate the option of including such impacts.

Methodology

Review of the literature

It will be necessary to review the relevant articles and reports related to CCS. A primary focus must be on costs of CCS and the anticipated pace of introduction of new technology. Further, the literature must be queried to determine the price responses of consumers to changes in electric consumption. This will allow a determination of what the loss of demand for coal generated electricity in West Virginia will be. In addition, the literature will be searched to determine the costs of switching to alternative or renewable fuels. So long as CCS is cost competitive with these substitutes the loss of markets will be reduced.

Consultation

Much, if not most, of the relevant information and data will have to come from the electric and coal industries themselves. Extensive work has already been accomplished on CCS by them. In addition there have been major studies by university based and private research organizations[75]. That work will be incorporated into the analysis.

Statement of assumptions

For any analysis to proceed, certain key assumptions must be made and clearly identified. The validity of the analysis will rest on the validity of the assumptions. Different assumptions will lead to different outcomes. Considering that West Virginia electricity is primarily exported to users out of state, all assumptions must be region wide and not limited to West Virginia. Among the assumptions to be considered are:

- The current and projected costs of CCS under various technologies
- The level of demand response to increased prices for coal generated electricity
- The costs and availability of alternate fuels
- Uses and markets for CO_2
- Public policies regarding CO_2

[75] For a summary see: Kentc. A. and Truex, E.D.(March 24, 2010) Carbon Capture and Storage: Issues and Policies in Appalachia. Presented at the Southern Regional Science Association Meeting, Washington, DC.

Development of scenarios

For that reason it may be necessary to develop alternative scenarios using different sets of assumptions in order to capture as many as possible of the projected outcomes. What scenarios would be considered would have to be a decision based on input from affected parties. The choice of scenarios would have to be limited to those "most likely" to happen or those with the greatest public support or concern.

Analysis

The analysis dynamic must use a dynamic economic model. The most widely used is REMI. REMI allows for a determination of the impact on income, output and employment from alternative public policies. It can project outcomes up to 20 years. It also can pinpoint the impact of those policies by most major industries. The output from the model would be translated into both written and graphic formats for distribution.

Review

The analysis should have extensive review and comment prior to public distribution. It should be considered by those who have consulted on the project as well as additional reviewers familiar with CCS and electric energy markets.

Distribution

Following the review and inclusion of the results of that review, the report should be made public. Particular attention should be made to placing it in the hands of the decision makers. An analysis this complex would take at least a year for completion.

Summary

The feasibility of implementing CCS in West Virginia depends on the relative impact of doing so in the region. Other states in the region will also be affected and have different resources that can be used to meet the requirements of CCS. Isolating West Virginia's share of the impacts will require developing 20 to 40-year assumptions related to market share of power generation, coal production, alternative fuel production, energy efficiency, and the complexities of the industry of carbon storage itself. Assumptions regarding technology and the timeframe of implementation are equally important. Considering the importance of coal to the West Virginia economy an analysis of CCS impacts would provide important information for both industry and government. The sub-committee on feasibility recommends such a study be completed.

Question 2: What factors need to be addressed to be able to assure the citizens of West Virginia that CCS is safe in terms of human health and the environment?

IV.A.5. What potential environmental and health related factors need to be addressed prior to reaching a decision regarding the feasibility of encouraging CCS in West Virginia?

The known potential human and environmental issues relevant to the feasibility of CCS include asphyxiation; explosiveness; risk to groundwater; effects on plant life; effects on seismic activity; effectiveness of CCS as a means of decreasing greenhouse gas emissions; increases in energy requirements due to efficiency losses; increases in water use; and increases in other air emissions.

Three avenues of release of CO_2 to the surface where it can present a human hazard are pipeline leaks, well leaks and seepage through the subsurface to ground level.

Asphyxiation

CO_2 is heavier than air and when concentrated it can pool near the ground, displacing oxygen. Proper siting, construction, maintenance and monitoring of CO_2 injection wells is vital to avoiding leaks into confined spaces such as basements, cellars, or other structures in or near the storage field. Should a well blowout or pipeline leak occur out in the open, the CO_2 likely would disperse quickly enough as to pose minimal risk of asphyxiation of human and animals.

Explosiveness

Unlike natural gas, CO_2 is not flammable. However, in order to maintain the supercritical or dense phase state, it is transported under high pressures. A sudden release of pressure due to a pipeline puncture would be 'explosive' in character but not flammable. There would be, however, considerable potential for harm to humans and animals in the immediate area of such an explosion.

With respect to transport, it should be noted that 3,769 miles of CO_2 transport pipeline are already in place in the U.S., and during the period 1994-2006, 18 "incidents" resulted in no fatalities or injuries (See Table IV.B.3). Based on historical data, the probability of injuries and fatalities from CO_2 pipeline "incidents" appears much lower than that for natural gas transmission pipelines. Still, extreme care should be taken in decisions as to siting of pipelines, operation of the pipelines to minimize possible corrosion, and implementation of effective risk management and mitigation plans.

Risks to groundwater

The protection of groundwater throughout a CCS project is vital to the water resources in West Virginia. Risks to groundwater quality arise from the potential for CO_2 to mobilize organic or inorganic compounds, acidification and contamination by trace compounds in the CO_2 stream, intrusion of native saline groundwater into drinking water aquifers, and the potential for the CO_2 to displace subsurface fluids. The probability of many of these risks occurring may be decreased by a thorough site characterization, sound injection well construction, sufficient monitoring, and enforcement of existing regulations. More detail can be found in Section IV.B.

Effects on plant life

Elevated levels of CO_2 in the soil from well leaks, pipeline leaks or seepage can negatively affect soil ecosystems and potentially kill plants if sufficient oxygen displacement and/or soil acidification occurs. Proper siting, construction, maintenance and monitoring of CO_2 injection wells is vital to avoiding leaks into soil. See Section IV.B regarding injection well construction.

Seismic activity

Proper siting of CO_2 storage reservoirs and proper injection procedures are vital to avoid inducing seismic activity. Geomechanical considerations include:

- Avoid regional tectonic stress near breaking strength of rock
- Avoid potential reservoir where fracture porosity is dominant
- Avoid low permeability reservoirs
- Avoid injection rates that can significantly increase pore pressure over a wide area.

Effectiveness

Does CCS make coal "carbon neutral"?

The goal for carbon capture from stationary sources is 90 percent. Modeling of IGCC, NGCC and pulverized coal (PC) technology[76] shows capture from gross power output (see Tables A.4 and A.5) between 86.98% (ConocoPhillips IGCC) and 89.44% (GE IGCC). Capture measured at net power output is between 88.33% (NGCC) and 85.26% (subcritical PC).

What is the likelihood the CO_2 will "stay put" after it's injected?

If it does not, then all our efforts and expense are for naught. Regarding retention of sequestered CO_2, the Intergovernmental Panel on Climate Change has stated that "Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years."[77]

Impact of capture technology on power generation

The amount of energy required to power carbon capture equipment increases parasitic load (see Total Auxiliaries Table A.4) reducing the net output of electricity. Each technology was modeled to maintain either gross power output for gas turbines or net power for steam turbines[78]. For each technology modeled, the difference with and without capture equipment is posted in Table IV.A.4 and the percent change is posted in Table IV.A.5. Compensating for this increase in parasitic load, 45.49% to 57.28% for IGCC technology and 288.21% to 290.07% for NGCC and PC technology is reflected in the increase consumption of coal by 2.19% to 4.54% for IGCC technology and 42.63% to 47.72% for PC technology. This combination of higher parasitic load and higher fuel consumption to compensate decreases the efficiency of coal plants by an amount ranging from 14.92% to 22.14% or IGCC technology and 30.43% to 32.34% for pulverized coal technology (see Tables IV.A.4 and IV.A.5). If CCS is employed on a large scale, therefore, significant additional amounts of coal may be consumed to maintain electricity generating output. If the additional coal consumption is focused on pulverized coal technology instead of IGCC technology, the amount of coal required is expected to increase by more than 42% (Table IV.A.5). This will result in a concomitant increase in coal-related environmental, property and human health effects; these include, but are not limited to, water pollution, land degradation, loss of ecosystem services, flooding, generation of slurry from the processing of coal, damage to roadways from heavy coal trucks, and coal ash disposal.

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[76] NETL, 2007, Cost and Performance Baseline for Fossil Energy Plants. DOE/NETL 2007/1281. Found at: http://www.netl.doe.gov/energy-analyses/baseline_studies.html

[77] IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H.C. de Coninck, M. Loos, and L.A. Meyer (eds)]. Cambridge University Press, Cambridge, United Kingdon and New York, N.Y., USA, 442 pp.

[78] Ibid 71, see exhibits 3-18 & 3-34, 3-51 & 3- 67, 3-84 & 3-100, 4-7 & 4-17, 4-28 & 4-38, 5-7 & 5-17.

Increases in water requirements

Tables IV.A.4 and IV.A.5 show that CCS is expected to increase water requirements for coal plants by an amount ranging from 10.06% (Conoco-Phillips IGCC) to 126.95% (subcritical PC).

Effects on other air emissions

Tables IV.A.4 and IV.A.5 also show that, while CCS will result in decreased emissions of SO_2 and NO_x at IGCC plants, emissions of NO_x, particulates and mercury will increase at pulverized coal plants. This could necessitate the installation of additional pollution control equipment in order to comply with permit requirements.

Table IV.A.4

Change in power generation, consumption of raw materials and generation of by-products due to installation of Carbon Capture equipment[79]

		Changes due to installation of Capture Equipment				
	General Electric Energy IGCC	Conoco Phillips E-Gas™ IGCC	Shell Global Solutions IGCC	Subcritical PC	Supercritical PC	NGCC
Gas Turbine/Steam Turbine Power – kWe	-290	-30	-400	96,608	83,185	0
Sweet Gas Expander Power – kWe	-870	-	-	-	-	-
Steam Turbine Power – kWe	-24,230	-48,640	-54,065	-	-	-50,110
Total Power – kWe	-25,390	-48,670	-54,465	-	-	-50,110
Total Auxiliaries – kWe	59,185	56,460	64,250	97,440	87,340	28,360
Net Power – kWe	-84,575	-105,130	-118,715	-832	-4,155	-78,470
Net Plant Efficiency - %(HHV)	-5.7	-7.6	-9.1	-11.9	-11.9	-7.1
Net Plant Heat Rate (Btu/kWe)	1,583.0	2,076.0	2,368.0	4,448.0	3,813.0	1,094.0
Consumables						
As-Received Coal/NG Feed - (lb/h)	10,745.0	13,966.0	20,556.0	208,890.0	175,345.0	0.0
Thermal Input – kWt						
Raw Water Usage - m^3/min (gpm)	575.0	378.0	771.0	7,886.0	6,718.0	2,168.0
SO_2 (lb/MWh)	-0.019	-0.022	-0.004	Negligible	Negligible	Negligible
No_x (lb/MWh)	-0.040	-0.033	-0.025	0.164	0.143	0.006
Particulates (lb/MWh)	0.003	0.005	0.007	0.030	0.027	Negligible
Hg (lb/MWh)	0.3×10^{-6}	0.4×10^{-6}	0.5×10^{-6}	2.7×10^{-6}	2.4×10^{-6}	Negligible
CO_2(Gross) (lb/MWh)	-1,305.0	-1,263.0	-1,260.0	-1,555.0	-1,472.0	-697.0
CO_2(Net) (lb/MWh)	-1,549.0	-1,477.0	-1,459.0	-1,608.0	-1,519.0	-704.0

[79] NETL, 2007, Cost and Performance Baseline for Fossil Energy Plants. DOE/NETL 2007/1281. Found at: http://www.netl.doe.gov/energy-analyses/baseline_studies.html

Table IV.A.5

Percent change in power generation, consumption of raw materials and generation of by products due to installation of Carbon Capture equipment.

		Changes due to installation of Capture Equipment				
	General Electric Energy IGCC	Conoco Phillips E-Gas™ IGCC	Shell Global Solutions IGCC	Subcritical PC	Supercritical PC	NGCC
Gas Turbine/Steam Turbine Power – kWe	-0.06%	-0.01%	-0.09%	16.56%	14.34%	0.00%
Sweet Gas Expander Power – kWe	-12.20%	-	-	-	-	-
Steam Turbine Power - kWe	-8.11%	-17.47%	-19.04%	-	-	-25.05%
Total Power – kWe	-3.30%	-6.55%	-7.28%	-	-	-8.79%
Total Auxiliaries - kWe	45.49%	47.39%	57.28%	296.44%	290.07%	288.21%
Net Power – kWe	-13.21%	-16.86%	-18.67%	-0.15%	-0.76%	-14.00%
Net Plant Efficiency - %(HHV)	-14.92%	-19.34%	-22.14%	-32.34%	-30.43%	-13.98%
Net Plant Heat Rate (Btu/kWe)	17.74%	23.91%	28.51%	47.95%	43.72%	16.28%
Consumables						
As-Received Coal/NG Feed - (lb/h)	2.19%	3.01%	4.54%	47.72%	42.63%	0.00%
Thermal Input – kWt						
Raw Water Usage - m^3/min (gpm)	14.36%	10.06%	20.33%	126.95%	123.47%	86.31%
SO_2 (lb/MWh)	-20.21%	-24.18%	-4.55%	Negligible	Negligible	Negligible
No_x (lb/MWh)	-9.85%	-7.62%	-6.05%	26.75%	24.70%	10.00%
Particulates (lb/MWh)	5.66%	9.62%	14.00%	26.32%	25.23%	Negligible
Hg (lb/MWh)	7.14%	9.52%	12.50%	27.00%	21.28%	Negligible
CO_2(Gross) (lb/MWh)	-89.44%	-86.98%	-89.43%	-87.36%	-87.57%	-89.02%
CO_2(Net) (lb/MWh)	-88.26%	-85.38%	-88.00%	-85.26%	-85.67%	-88.33%

IV.A.6. Incentives for CCS Technology

The decision concerning whether or not to take steps to provide incentives for the deployment of CCS Technology in West Virginia obviously must come subsequent to determining whether or not this technology is feasible. However, in advance of that determination, the Legislature has tasked the Working Group with researching plausible incentives.

Regulatory Certainty

Regulatory certainty is arguably the single most important step the state can take to incentivize deployment of CCS technology in West Virginia. To that end, the legal issues concerning pore space ownership and liability for sequestered CO_2 need to be resolved and are being considered by the Working Group. A clearly defined set of regulations and a definitive agency authority needs to be named to handle these projects. Further, a multi-agency team should be formed to address all issues for a permit applicant during the submittal process. At a minimum this would include WVDEP, PSC, WVDNR, WVEGS and WVDO.

The American Clean Energy and Security Act (ACES Act)

While the ACES Act has not been promulgated, it remains the most viable bill currently being considered by Congress concerning a carbon cap-and-trade program. Language in the bill also promotes R&D and early deployment of CCS primarily by the creation of a carbon storage research corporation which uses funds to issue grants and financial assistance for commercial scale CCS projects. The bill proposes funding of $1.1 billion per year for no more than 10 years. If the Act or an Act with similar provision is passed by Congress, the Working Group recommends that the Governor charge the West Virginia Development Office to make an extraordinary effort to make use of these monies by mandating at least one grant application be submitted each year.

The ACES Act also proposes to provide allowances to the first facilities that implement capture and secure geologic storage that results in a 50% reduction in annual CO_2 emissions. The West Virginia Alternative and Renewable Portfolio Standards Act, promulgated in 2009, places a mandate on the electric industry to utilize renewable and alternative fuels, and does allow generators to meet the standards by employing CCS. This legislation should be reviewed to ensure that West Virginia is maximizing the incentive and that it is actually useful for generators as written.

The American Recovery and Reinvestment Act (ARRA)

The ARRA was passed by Congress in 2009 and included tax incentives for CCS technology. It expanded tax credit bonds allocated to states and large local governments to finance clean energy projects including those incorporating CCS technology. There was also money made available for an “advanced energy property investment credit” providing 30% credit for investment in property designed to capture and sequester CO_2 as part of a qualified advanced energy manufacturing project. After consulting with the West Virginia Department of Tax and Revenue to explore whether a similar property tax credit for West Virginia is feasible, the Working Group has learned that there are many tax credits available in West Virginia for R&D, business expansion, and pollution control devices. The Feasibility Subcommittee will perform further research to ensure that the existing credits are accessible for those willing to invest in CCS technology in the state so that the state credits may dovetail the federal incentives.

Rate Incentive

The PSC is currently directed to provide rate incentives for clean coal technologies which reduce SO_2 and NO_x emissions via the following law:

> **§24-2-1g. Rate incentives for utility investment in qualified clean coal and clean air control technology facilities.**
>
> (a) The Legislature hereby finds and declares that the state of West Virginia has been a major supplier of coal to the electric power industry both within and outside of the state of West Virginia; the congress of the United States is currently considering legislation to limit the emissions of oxides of sulfur and nitrogen from coal-fired electric generating plants; the continued use of coal for generating electrical energy can be accomplished in an environmentally acceptable manner through the use of current state of the art and emerging clean coal and clean air technology; it is in the interest of the economy of West Virginia to encourage the use of such technologies for the production of electricity and steam; revenues from the continued production of coal are important to the State of West Virginia and are necessary for the funding of education and other vital state services; the construction of electric utility generation and transmission facilities may continue for many years following the finalization of plans for such facilities; and the prudence of the construction of such facilities may be affected by changing conditions during the extended interval between finalization of plans and completion of construction.
>
> (b) Upon a finding that it is in the public interest of this state, as provided in section one, article one of this chapter, the public service commission shall authorize rate-making allowances for electric utility investment in clean coal and clean air technology facilities or electric utility purchases of power from clean coal technology facilities located in West Virginia which shall provide an incentive to encourage investments in such technology
>
> (c) For purposes of this section a qualified clean coal or clean air technology facility must use coal produced in West Virginia for no less than seventy-five percent of its fuel requirements.
>
> (d) The public service commission shall determine, at such time and in such proceeding, form and manner as is considered appropriate by the commission, the extent to which any electric utility investment or purchases of power qualify for incentive rate-making pursuant to this section.

The Working Group suggests that a bill be proposed that adds CCS technology to this law.

Pre-qualifying Storage Sites

"Pre-qualifying" storage sites would entail a group of state agencies taking steps to locate and ensure the viability of potential sites as locations to sequester CO_2. Many factors would be considered such as topography, infrastructure, geology, etc. While entities would still be required to follow the normal permitting process that is established, investment in the process would be incentivized given that initial steps have been taken to certify that the storage site is permittable. This procedure will be further investigated by the Feasibility Subcommittee.

IV.A.7. Property Taxation and CCS

The Working Group has not considered the property tax implications, if any, of either the stored CO_2 or the value of the right to use the pore space for CO_2 storage.

IV.A.8. Conclusions

1. The timeline for requirements to restrict the emissions of greenhouse gases is, at present, uncertain. However regulation at some point in the next few years is near certainty.

2. The task of reducing greenhouse gas emissions to the levels that many contend are necessary to avoid negative impacts of predicted climate change is monumental and will require major changes in the manner of producing and using energy. There is currently no proposed technology or acceptable life style adjustment that can meet these goals. In short, no one currently knows how to meet the projected goals for GHG reduction.

3. Carbon Capture and Sequestration is one of many tools that can be used to meet the goals of reducing carbon emissions. The development and deployment of CCS may also allow West Virginia to continue to use its current electrical power generation infrastructure and coal supplies.

4. Technology that is commercially able to capture and store carbon dioxide emissions from coal fired electric generation is not currently available.

Question 3: What are the technical issues (both engineering and geological) that must be addressed to ensure the efficacy of CCS in West Virginia?

IV.B. GEOLOGY & TECHNOLOGY REPORT

IV.B.1: Introduction

The Geology & Technology Subcommittee was asked to focus on three questions posed in the legislation: identifying monitoring sites for geologic sequestration W.Va. Code §22-11A-6(h)(5), assessing the feasibility of carbon dioxide sequestration in W.Va. Code §22-11A-6(h)(6), and assessing the potential carbon dioxide sequestration capacity in the state W.Va. Code §22-11A-6(h)(8). All three subcommittees were asked to address three other questions posed in the legislation: assess the economic and environmental feasibility of large, long-term carbon dioxide sequestration operations W.Va. Code §22-11A-6(h)(2), identify areas of research needed to better understand and quantify the processes of carbon dioxide sequestration W.Va. Code §22-11A-6(h)(9), and outline the working group's long-term strategy for the regulation of carbon dioxide sequestration in West Virginia W.Va. Code §22-11A-6(h)(10). The Geology & Technology Subcommittee worked in conjunction with the Legal Subcommittee to outline a response to question 10, the working group's long-term strategy for the regulation of carbon dioxide sequestration in West Virginia. It addressed several technical questions referred to it by other subcommittees. West Virginia has a history of oil & gas and coal production and both indicate the potential for sequestration of captured CO_2 in depleted oil & gas reservoirs as well as in unmineable coal seams. Even more important for potential CO_2 sequestration is the storage potential in saline formations or reservoirs which represents between 68 and 89 percent of the total storage potential in West Virginia (Table IV.B.9). Initial estimates of the geologic storage capacity for carbon dioxide in West Virginia, at 90 percent capture rates, suggest that there is between 74 years and 227 years[80] of injection for the annual carbon dioxide emissions from 27 sources in West Virginia (Table IV.B.10). The Midwest Regional Carbon Sequestration Partnership (MRCSP) has identified several stratigraphic horizons that may have potential for sequestration.[81] Their work, along with the other six Regional Carbon Sequestration Partnerships, is combined into the NATCARB database. These values for storage potential will be revised as additional information is obtained regarding the suitability of geologic formations for sequestering captured CO_2.

USEPA published their Underground Injection Control (UIC) program Class VI rules in the Federal Register in December 2010. The primary purpose of UIC regulations is the protection of US drinking water (USDW). USEPA also published, at the same time, Subpart RR, an additional section under their mandatory greenhouse gas reporting rule to cover carbon sequestration operations. The mandatory greenhouse gas reporting rules are design to track GHG emissions. Compliance with Subpart RR provides USEPA with the data it needs to confirm that sequestered CO_2 remains in the reservoir. Working together, both sets of regulations will require establishment of a monitoring, verification and accounting (MVA) system per NETL terminology or a Monitoring, Reporting and Verification (MRV) plan per Subpart RR, to confirm the position of the CO_2 plume in the reservoir as well as detect possible leakage. Initial MVA activity will be based on baseline information established prior to operations for future reference. Site characterization activities integrating surface and subsurface data will improve understanding of the geologic setting in preparation of the five plans required for application for a Class VI permit; Area of Review (AoR) and corrective action, monitoring and testing, injection well plugging, post-injection site care (PISC) and site closure and emergency and remedial response. With the publication of their Class VI rules and Subpart RR, regulations and permitting standards for Class VI permits are now known. It will now be necessary to provide appropriate legislation and supporting regulations at the state level that address regulatory gaps not covered by Federal regulations. It is also appropriate to develop the necessary expertise within state agencies to oversee this developing regulatory framework and growing industry.

Assessment of the risks associated with storing carbon dioxide is necessary and essential in developing suitable operation plans and provide for financial responsibility. USEPA requires financial responsibility for corrective action, injection will plugging, post-injection site care and site closure and emergency and remedial response. These financial responsibility requirements dovetail with the operations plans and are designed to assure the leakage pathways are sealed and USDWs are protected.

[80] NETL, 2010, Carbon Sequestration Atlas of the United States and Canada, third edition. Found at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIII/index.html

[81] Wickstrom, L.H. et al., 2005, Characterization of Geologic Sequestration Opportunities in the MRCSP Region, Phase I Task Report Period of Performance: October 2003-September 2005, DOE/NETL DE-PS26-05NT42255

It is also important to assess risks associated with transportation of captured CO_2 across West Virginia to CO_2 storage fields, either in state or in another state. Since the early 1970's, carbon dioxide has been transported and injected into the subsurface for the purpose of enhanced oil recovery. Although this network of CO_2 pipeline and EOR fields is the most extensive such network in the world, it is small relative to the scale envisioned for CCS in the United States. There is a substantial and growing body of carbon dioxide risk assessment literature. Analogous areas of experience such as natural gas transportation and storage, underground injection of wastes and EOR suggest that carbon dioxide can be safely transported and stored. It does not imply that accidents will not happen. Should climate legislation be enacted requiring reduction on CO_2 emissions, the scale of transportation and injection of captured CO_2 will grow considerably, increasing exposure to risk. Actual operations in carbon sequestration will establish the safety record for this particular industry.

IV.B.2: Assess the economic and environmental feasibility of large, long-term carbon dioxide sequestration operations [§22-11A-6(h)(2)]

Sequestration of captured carbon dioxide is a long-term effort in locating and characterizing a suitable location, gaining the necessary permits, injecting the CO_2, monitoring this injection to assure sequestration, monitoring post-injection to assure sequestration and then long-term stewardship to assure sequestration. This whole process is illustrated in Figure IV.B.2 and incorporates recent regulations published for Class VI injection wells to assure protection of USDWs and Subpart RR to assure the CO_2 injected for sequestration remains in the reservoir.

Sequestration of captured CO_2 is the opposite of producing oil & gas. Both involve a reservoir with porosity, the storage space, and permeability, the connection between pores. Oil & gas production is a pressure depletion process removing the oil & gas from the pore space but CO_2 sequestration will increase the pressure of the reservoir, pushing CO_2 into available pore space. It is this increase in pressure that is the challenge of carbon dioxide sequestration. Elevated reservoir pressure will move captured CO_2 through the reservoir, displacing fluids already in place. This elevated pressure and the displacement of in situ formation fluids are the primary concerns addressed by the UIC Class VI regulations. USEPA set a default 50 year time period for post-injection site care because it believed that this was the necessary time needed for elevated formation pressures to return to original in situ reservoir pressures, establishing non-endangerment. The operator can, per regulations, request a shorter time period.[82]

IV.B.2.a: Economic Feasibility of Saline Carbon Dioxide Sequestration

Saline storage provides the major opportunity in sequestering captured CO_2. The cost of sequestering captured CO_2 is often expressed in dollars per metric ton or tonne. In their economic analysis of Class VI regulations, USEPA estimated that sequestration will cost about \$3.80 per tonne.[83] Earlier modeling calculated sequestration costs between \$0.05 and \$8.00[84]

[82] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf.

[83] Ibid

[84] IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H.C. de Coninck, M. Loos, and L.A. Meyer (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, N.Y., USA, 442 pp.

while a more recent analysis estimated storage costs at $6.00 per tonne for a good reservoir and $13.00 per tonne for a poor reservoir.[85] At the 10th Annual CCS Conference in Pittsburgh, John Tombari of Schlumberger Carbon Services, during a presentation on storage costs, said that 100 Mt of captured CO_2 can be sequestered for between $5.00 and $10.00 per tonne.[86] These values do not include financial responsibility or transportation and only represent about 5 to 10 percent of the total cost of carbon capture and storage (Table IV.B.1). These costs appear reasonable yet they hide the challenge and risk involved in selecting, characterizing, operating and closing a sequestration operation.

Table IV.B.1: Carbon Capture and Sequestration cost components

CCS Component	Technology	NETL[1] (2007)	Global CCS Inst[2] (2011)	IPCC[3] (2005)
Capture: Power	Subcritical-PC	68		
	Supercritical-PC	68	62 - 81	
	IGCC	32 - 42	67	
	NGCC	83	107	
	Oxy		47 - 59	
Capture: Industry	Steel - Blast Furnace		54	18
	Steel – direct induction			10
	Cement		54	
	NG Plant		19	10
	Oil Refinery			55
	Ethanol			10
	Fertilizer		20	
	Ethylene or Ammonia			10
Transportation			1 - 2	1 - 8
Storage			6 - 13	0.5 - 8
All costs are $/tonne 1 – NETL, 2007, Cost and Performance Baseline for Fossil Energy Plants 2 – Global CCS Institute, 2011, Economic Assessment of Carbon Capture and Storage Technologies 3 – IPCC, 2005, Carbon Dioxide Capture and Storage				

A considerable amount of work to establish CO_2 injection operations has to be accomplished before actual injection and positive cash flow begins. Initial regional geologic analysis may take up to a year and should yield a list of prospects from which a specific location is selected for actual site characterization and permitting. During site characterization, five plans are prepared for submittal on application for a Class VI injection well permit: Area of Review (AoR) and corrective action, monitoring and testing, injection well plugging, post-injection site care (PISC) and site closure, and emergency and remedial response plans. Assembling these plans will require analysis of seismic, well, core, geochemical and geomechanical data. New wells will need to be drilled, cores taken from these wells, new 3-D seismic acquired, processed and interpreted. All old wells within the Area of Review will have to be identified and evaluated as to whether or not they were properly plugged and abandoned. If not then these wells will require remediation, the corrective action done during injection operations. The right to inject captured CO_2 into the reservoir pore space will have to be secured prior to application for a

85 Global CCS Institute, 2011, Economic Assessment of Carbon Capture and storage Technologies.
86 Presentation at 10th Annual CCS Conference, May 2-5, 2011, Pittsburgh, Pa.

permit. More than enough acreage will have to be secured to provide sufficient areal extent of the CO_2 plume many decades in the future when injection operations cease. Acreage acquisition will be an exercise in public relations, explaining the purpose of the storage field to the wider community under which the future CO_2 plume will reside. The whole exercise of site characterization will be a public relations, or outreach, effort.

Looking at some basic site characterization costs, John Tombari of Schlumberger Carbon Services estimates a few years ago that it will cost $100,000 per square mile to acquire 3-D seismic and $3,000,000 to drill and log an evaluation well plus 30% of these costs for data processing, modeling and other services[87]. He estimates that one well will evaluate 25 mi^2. It should be point out that seismic coverage has to extend beyond the boundaries of the CO_2 plume, or potential reservoir, to provide good data imagining. With 3-D seismic and one new well with modern data, characterizing a storage field bounded within 25 square mile area will cost a little over $7,000,000. These costs do not cover all of the details that need to be accounted for in preparation of the several plans required for application of a Class VI permit, for example spotting all plugged and abandoned wells, establishing geochemical baselines, providing financial responsibility, as well as presenting a storage field proposal before a regulatory body with the intent of gaining a permit.

Two recent studies looked at storage costs. The Global CCS Institute estimated storge site characterization cost to be $25 million on average with a range of $10 to $150 million. Their study recommended assembling a list of six to eight prospects from which to select a site for characterization. There is some probability that the first site selected will not meet expectations and will have to be abandoned for another site. In their modeling they assumed a characterization cost of $60 million. The higher cost estimate from the Global CCS Institute's study suggests a 17 percent success rate.[88] Taking a global perspective, the International Energy Agency (IEA) looked at CCS storage costs with respect to meeting the goal of having 20 large scale CCS projects active by 2020. Their cost estimates ranged from €9 million to €81 million with an average of €30 million. At the current exchange rate of $1.44 per Euro, these costs are $13 million to $117 million with an average of $43 million.[89] The Global CCS Institute model assumed that it will take up to nine years before injection can begin. The IEA model assumes a similar time frame at a minimum. In Table IV.B.2, an estimate of between 3.5 and 6 years is needed for regional geologic evaluation, site selection and characterization and permitting. If storage costs range from $5.00 to $10.00 per tonne as noted above from comments by John Tombari of Schlumberger, then sequestering 100 million tonnes of CO_2 can cost between $500 and $1,000 million dollars. With site characterization costs through permitting of $60 million, then it is easy to see that the majority of expenses incurred by sequestration occur after injection begins, driven by MVA activity and tracking the CO_2 plume.

Early developers for CO_2 storage sites will not have to worry about competitors and their success rate in selecting a successful location should be reasonable. Exploration success in the

[87] McCoy, S.T., 2008, The Economics of CO_2 Transportation by Pipeline and Storage in Saline Aquifers and Oil Reservoirs. PhD dissertation, Carnegie Mellon University, January, 2008.

[88] Glogbal CCS Institute, 2009, Strategic Analysis of the Global Status of Carbon Capture and Storage, Report 2: Economic Assessment of carbon Capture and Storage Technologies. Found at: http://www.globalccsinstitute.com/sites/default/files/Report%202-Economic%20Assessment%20of%20Carbon%20Capture%20and%20Storage%20Technologies_0.pdf

[89] IEA, 2011, Global Storage Resource Analysis for Policymakers, IEA CCS Costs Workshop, Paris, March 22-23, 2011. Found at: http://www.ieaghg.org/docs/General_Docs/IEAGHG_Presentations/Gap_Analysis_IEA_CCS_NW_Mar11_v2.pdf

oil and gas industry use to be in the 10 percent range. This improved to the mid-thirty percent range with the development of 3-D seismic.

Completion of the five plans required for permit application (Table IV.B.2) will drive site characterization costs. The size of the Area of Review is critical as this is related to the size of the CO_2 plume. The areal extent of the CO_2 plume will indicate the amount of acreage needed to secure pore space rights, the extent of the MVA network, the extent of seismic needed, the number of old wells that will require remediation under corrective action, and the number of monitoring wells. Permeability and the volume of CO_2 to be injected daily will determine the number of injection wells so the required injection well plugging plan is relatively straight forward. The overall MVA network and number of monitoring wells required will be explained in the monitoring and testing plan. The post-injection site care and site closure plan will be based on the other plans and is required to be updated after the injection operations cease prior to post-injection site care. The emergency and remedial response plan looks at the risk of leakage and the necessary response and is based on the geologic analysis done in preparation for the AoR. This plan will be funded by the Financial Responsibility plan that the operator will have established prior to permit application. Preparation of these plans is not a static exercise. The AoR has to be updated at a minimum of every five years and any revisions will require project modification of the other plans, including financial responsibility. There are also annual reporting requirements, specifically for mechanical integrity test (MIT) of the injection wells.

Financial responsibility is an important aspect of the Class VI regulations and expense for overall operations and is broken into four parts: corrective action, injection well plugging, post-injection site care and site closure, and emergency and remedial response. Instruments that can satisfy this requirement include trust funds, surety bond, letter of credit, insurance, self-insurance, escrow account and other instruments approved by the Director [40 CFR 146.85(1)]. For self-insurance, the net worth of the operating company or owner must be greater than $100 million.[90] The Wyoming Carbon Sequestration Working Group estimates that $77 million would cover the financial responsibility in sequestering about 60 Mt of CO_2 over a nine square mile area (Table IV.B.3).[91] This estimate does not include corrective action, remediation of old well bores. USEPA estimates that it will cost about $850 thousand to fulfill corrective action obligation on 29 deep, shallow and ground water wells in their base case saline scenario.[92] Rounding up to one million, then financial responsibility is valued at $78 million. Depending on how this is paid for, annual premiums or payments to an escrow account or trust fund, financial responsibility can add as much as $1.30 per tonne to sequestration costs. The majority of financial responsibility in Wyoming's analysis was for emergency and remedial response. Which financial instruments are used to cover this portion of financial responsibility will have an impact on sequestration costs.

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[90] EPA, 2010, Underground Injection Control (UIC) Class VI Program, Financial Responsibility Guidance – Draft. Office of Water (4606M, EPA 816-D-10-010, December 2010. Found at: http://water.epa.gov/type/groundwater/uic/class6/upload/uicclass6financialresponsibilityguidancedec2010.pdf

[91] Report and Recommendations of The Carbon sequestration Working Group to the Joint Minerals, Business and Economic Development Committee and the Joint Judicial Committee of the Wyoming State Legislature, September, 2009. Found at: http://deq.state.wy.us/out/downloads/1%20FinalReport081909.pdf

[92] EPA, 2010, Cost Analysis for the Federal Requirements Under the Underground Injection Control Program for Carbon Dioxide Geologic Sequestration Wells (Final GS Rule), Office of Water (4606M, EPA 816-R10-013, November 2010. Found at: http://water.epa.gov/type/groundwater/uic/class6/upload/uiccostanalysisforfederalrequirementsunderuicforco2nov2010.pdf

Table IV.B.2: Sequence of operational stages for a CO_2 sequestration.

Regional evaluation for a specific site	Site selection & characterization	Permitting	Operations	Post-Injection Monitoring	Long-term Stewardship
Negative Cash Flow			Positive Cash Flow Injection Fee	Negative Cash Flow	Trust fund covers costs
1. Regional geologic evaluation to identify several prospective areas for storage operations	5. Assemble data; acquire new data; drill new well(s) & acquire seismic; establish data baselines; get necessary permits	9. Submit all plans and financial responsibility for permit application – UIC & State	13. Finish construction of surface facilities and MVA grid; Tie injection wells to CO_2 supply.	17. Present PISC & site closure plan to Director; apply for reduced time period	21. Another entity accepts long-term stewardship
2. Data research – geologic, geophysical, engineering, financial & social	6. Finish assembling acreage block.	10. Director approves drilling of injection wells. PSC awards CPCN if needed. State (DEP) approves site permit.	14. Inject Captured CO_2, annual MIT for injection wells; well workovers as necessary.	18. Follow PISC & site closure plan, periodic testing and reporting.	22. Operator & other parties relieved of liability unless negligent, etc.
3. Estimate of volume of emissions to sequester and pore space needed over project life. Value of storage efficiency?	7. Prepare plans[1] required for UIC Class VI and state permits. FEED for injection wells, surface and MVA grid.	11. Drill injection wells, incorporate new data in plans and present to Director.	15. Drill additional monitoring wells and remediate existing wells as necessary as plume expands. Well workovers & equip. maintenance as necessary	19. Establish non-endangerment; closure approved; P&A all wells & restore site(s).	23. Other entity oversees trust fund, pays site costs, settles all claims
4. Begin to assemble acreage block. Will need more acreage than actually used +30 yrs later. Hopefully first site selected will prove correct.	8. Assemble financial responsibility package[2] for UIC and state permits.	12. Director approves injection. Have 180 days to submit MRV plan per Subpart RR regs.	16. Follow all plans; AoR review every 5 yrs, annual reporting. Pay into to fund for LT Stewardship; P&A injection wells, some financial responsibility instruments released.	20. With closure of Class VI permit, Director releases financial responsibility instruments. State (DEP) awards Certificate of Completion & assumes long-term stewardship.	
0.5 to 1 year	3 to 5 years		30 to 50 years	10 to 50+ years	Rest of Civilization

PSC – Public Service Commission
CPCN – Certificate of Public Convenience and Necessity
P&A – Plug and Abandon
Director – EPA or State if primacy is assigned

1 - Plans: Area of Review (AoR) and corrective action plan
Testing and Monitoring plan
Injection well plugging plan
Post-injection site care (PISC) & site closure plan
Emergency and remedial response plan

2 - Financial Responsibility for:
Corrective action
Injection well plugging
Post-injection site care & site closure
Emergency and remedial response

Corrective action may present a challenge for sequestration operations in West Virginia. Average well density[93], by county, in West Virginia varies between less than one well per square mile to just over 29 wells per square mile. In their economic modeling USEPA estimated that 10 percent of older wells will need remediation and another 15 percent will not have inadequate cement bond log data, requiring closer examination. With the higher well density there would be 261 older wells to list in the AoR and as many as 65 wells requiring some level of attention to assure that they are not a leakage pathway. Class VI regulations require that all wells within the AoR penetrating the injection or confining zones be listed [40 CFR 146.82(a)(4)]. This corrective action is required on all wells so determined [40 CFR 146.84(d)] and can be done in phases has the plume grows [40 CFR 146.84(b)(2)(iv)]. Corrective action with respect to the environmental aspect of saline sequestration is discussed in the Well Failure section of Environmental Feasibility of Saline Carbon Dioxide Sequestration.

Table IV.B.3: Wyoming Carbon Sequestration Working Group estimate of Financial Responsibility compared to EPA Financial Responsibility categories.

Million $	Type of Responsibility	USEPA
22	Extensive relief well & water treatment mitigation	Emergency & Remedial Response
15	Water Quality contamination during the fluid phase –Drinking water replacement	
	A single large release to the surface –relief well mitigation	
10	Chronic low-level releases to surface –relief well mitigation	
	Entrained contaminant releases –pump back and treatment systems	
	Storage rights infringement –relief well mitigation	
5	Modified surface topography –structural damages	
5	Accidents or unplanned events –surface clean-up	
55	Total	
2	Well plugging and abandonment (for 3 well field, each injection well has 3 monitoring wells)	Injection Well P&A
2	Facilities/pipeline D&D/abandonment	
2	Surface disturbance reclamation	
6	Total	
9	Post-Injection Monitoring (15 yrs)	PISC & Site Closure
1	Post-Injection inspection and maintenance	
2	Contractor contingencies for site closure & reclamation (15%)	
1	Field Management	
1	Unknowns for site closure & reclamation (10%)	
16	Total	
-	Corrective Action –remediate old well bores	Corrective Action
77	Total for Financial Responsibility	

[93] Data found at West Virginia Geological & Economic Survey

What will contribute to the failure of a particular site? Three things, lack of sufficient reservoir volume and/or injectivity and an inability to assemble sufficient acreage. Does a CO_2 storage field operator find a suitable reservoir then secure a source prior to final site characterization or does a source look for suitable storage space? Computer modeling will provide early assessment of reservoir potential but this model depends on data quality. Wells drilled to explore the potential reservoir may show a thin reservoir or lack of porosity (storage) or permeability (injectivity). Older 2-D seismic may indicate a reservoir of sufficient areal extent that new 3-D seismic does not confirm. Low porosity provides low storage capacity. Low permeability means low injectivity and more injection wells. Possible solutions in assembling acreage for a CO_2 storage project are discussed further by the Legal Subcommittee. After development of CO_2 storage fields are underway, regulators may determine that a new proposed storage field will encroach upon the AoR of an active field in the same geologic formation and deny the permit.

Natural gas storage in aquifers provides examples on the challenges and potential failure of these types of reservoirs. In 2008, there were 401 active natural gas storage fields: 34 salt caverns, 43 aquifer and 324 depleted oil & gas fields.[94] Total amount of gas in storage, 5.9 TCF, represents about 120 million metric tons (assuming pure methane)[95], slightly more than the 102 million metric tons of annual CO_2 emissions for West Virginia. As the numbers suggest, aquifer natural gas storage is much less desirable than depleted oil & gas reservoir storage. Depleted oil & gas reservoirs are known traps. Development of aquifer natural gas storage has a few drawbacks. Its geological characteristics are not as thoroughly known, as with depleted reservoirs. Some exploratory wells may need to be drilled to gather rock data (wireline logs and core samples), seismic data may be required to confirm the structural configuration of the trap and injectivity test may be necessary.[96,97] It can take up to four years to develop an aquifer natural gas storage field, twice the time needed for a depleted reservoir,[98] and a further ten or more years before the full extent of storage capacity is realized as the natural gas bubble is increased in area. Development of aquifer storage is a more exploratory procedure than for depleted reservoirs which impacts the economics for these particular projects.

Aquifer natural gas storage is a high pressure operation, exceeding hydrostatic but not fracture gradient pressures, required to displace formation waters and represents higher storage efficiency, approaching 100 percent, than what is expected for CO_2 storage (Table IV.B.9). This is necessary to create the bubble and provide for high delivery rates when the stored gas is produced and shipped to market. The high pressure nature of natural gas storage is the main cause of leakage.[99] Most of the leakage is through well failure although some natural gas may be lost at the margins of the bubble. Some operations will drill collector wells to recover natural gas that has escaped the reservoir.[100]

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[94] EIA, Underground Natural Gas Storage Capacity: http://www.eia.doe.gov/dnav/ng/ng_stor_cap_dcu_nus_a.htm

[95] Lawrence Berkeley National Laboratory article on "Relevance of Underground Natural Gas Storage to Geologic Sequestration of Carbon Dioxide" by Marcelo J. Lippmann and Sally M. Benson.

[96] Ibid

[97] Storage of Natural Gas, found at: http://www.naturalgas.org/naturalgas/storage.**asp**

[98] Lawrence Berkeley Natural laboratory article on "Relevance of Underground Natural Gas Storage to Geologic Sequestration of Carbon Dioxide" by Marcelo J. Lippmann and Sally M. Benson.

[99] Ibid

[100] Storage of Natural Gas, found at: http://www.naturalgas.org/naturalgas/storage.asp

Natural gas storage in aquifers typically is done at a site that appears to have appropriate structure and a trap to contain hydrocarbons. However, since no hydrocarbons were initially discovered in the formation, the nature and quality of the trapping mechanism is not well established. It raises questions about the containment and sealing capability of the apparent trap and the integrity and tightness of the caprock. The Manlove Storage Field in Champaign County, Illinois initially injected natural gas into a St. Peter sandstone reservoir. Natural gas was discovered in the overlying glacial drift shortly after injection began. Natural gas was then injected into the deeper Galesville sandstone but leakage was also detected. Drilling deeper, injection of natural gas was finally secured in the Mt. Simon sandstone because the overlying Eau Clair formation provided a suitable seal.[101]

Under the Statutory and Executive Order Review section of the final rule for Class VI wells, USEPA determined, per the Regulatory Flexibility Act (RFA) that sequestration of CO_2 is prohibitively expensive for small entities[102]. A reasonable conclusion considering that for an operator or owner of a CO_2 sequestration operation to utilized self insurance in compliance with financial responsibility must have a net worth greater and $100 million.

IV.B.2.a.1: CO_2-EOR (Enhanced Oil Recovery)

Carbon dioxide has been used to facilitate additional recovery of oil during tertiary recovery. This enhanced oil recovery (EOR) method was developed in the Permian basin of West Texas and eastern New Mexico the early 1970's and has steadily grown since. There are other EOR methods but the use of CO_2 is the most common. CO_2-EOR production is now applied to fields in Wyoming, Colorado, Oklahoma, Michigan, Mississippi and Louisiana. At the 8th Annual EOR Carbon Management workshop in Houston, Texas, EOR was presented as the market mechanism to drive deployment of CCS technology.

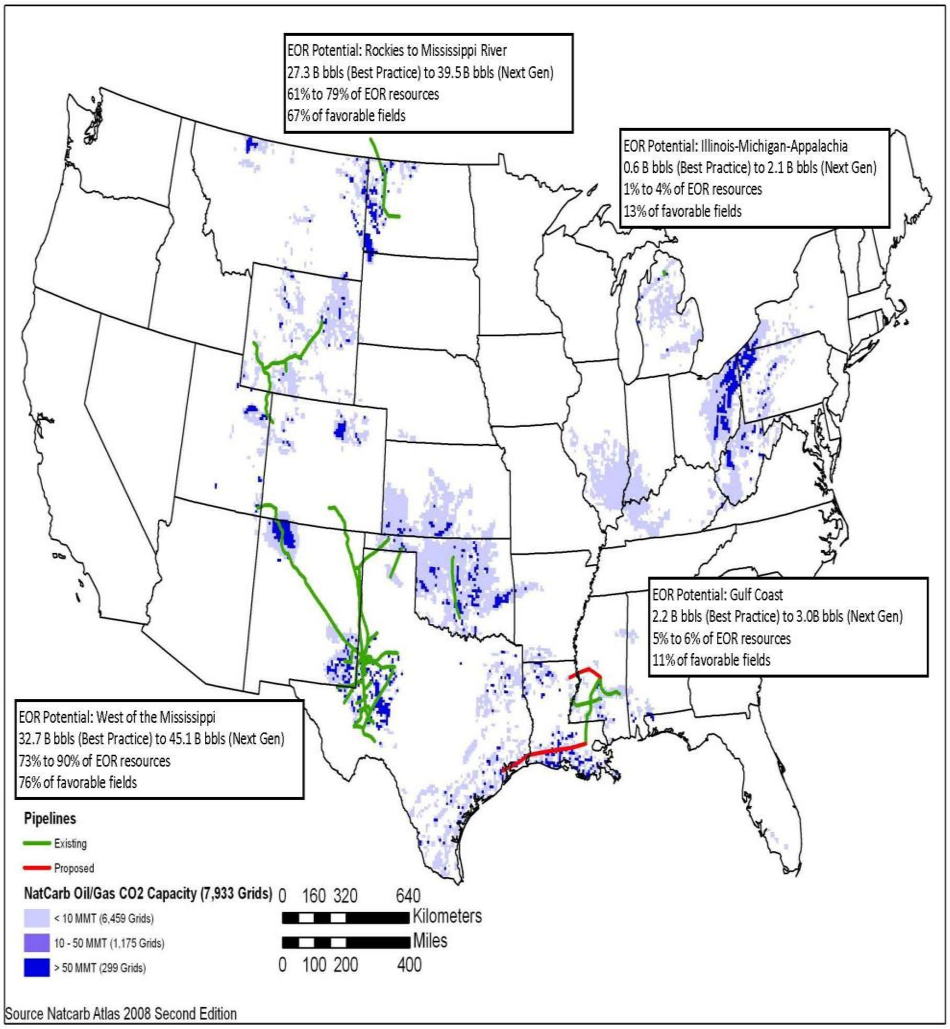
About half of the CO_2 injected for EOR operations is trapped in the reservoir, essentially sequestered. CO_2 recovered by production is recycled, reinjected into the reservoir. Presently, most of the CO_2 used by EOR is from natural sources with the balance from anthropogenic sources. In Table IV.B.1, natural gas plants as well as ethylene and ammonia plants have the lowest cost of capture.

There is a considerable amount of oil in the United States that can be recovered by EOR. Advanced Resources International, in a study done for NETL[103], estimated that, in the lower 48 states, as much as 50 billion additional barrels of oil are considered economically recoverable (Figure IV.B.1). Between 73 and 90 percent of these resources are west of the Mississippi River where 76 percent of the fields favorable for EOR are located. Only about 4 percent of potential EOR resources are considered to be recoverable from the Illinois-Michigan-Appalachian Basins where 13 percent of the favorable reservoirs are located. The opportunity for EOR in West Virginia needs to be examined. The opportunity to export captured CO_2 westward to the EOR market is non-existent at the moment due to lack of available pipeline connections. The longest

[101] Midwest Geological Sequestration Consortium, 2005, An assessment of Geological Carbon Sequestration Options in the Illinois Basin, Phase I Final Report. Found at: http://sequestration.org/publish/phase1_final_rpt.pdf
[102] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf
[103] NETL, 2010, Storing CO_2 and Producing Domestic Crude Oil with Next Generation CO2-EOR Technology: An Update. DOE/NETL-2010/1417

CO_2 pipeline is the Cortez pipeline at about 500 miles.[104] Denbury is conducting a feasibility study for construction of a CO_2 pipeline from Illinois/Indiana south to Mississippi or Louisiana.[105] The northern end of this pipeline may be within a reasonable distance of West Virginia sources. When this opportunity will be available is another question,

Figure IV.B.1: Distribution of potential EOR oil resource recovery.



[104] Report of the Interagency Task Force on Carbon Capture and Storage. Found at: http://fossil.energy.cov/programs/sequestration/ccstf/CCSTaskForceReport2010.pdf.

[105] http://www.denbury.com/index.php?id=53

IV.B.2.b: Environmental Feasibility of Saline Carbon Dioxide Sequestration

IV.B.2.b.1: Occurrence of Carbon Dioxide Sequestration Reservoirs

A reservoir in the subsurface is defined by the presence of porosity (storage space) and permeability (passage ways connecting pore space). Oil & gas reservoirs are accumulations of hydrocarbons that are trapped, either by a structural feature, by a sealing fault, by a flexure in the sedimentary formation creating a closed high (for example an anticline), by a change in sedimentary environment, or by a sandstone depositional environment changes to a shale depositional environment. A key component of this trap is the seal, a sharp change in permeability preventing further migration, but it does not necessarily prevent seepage. Hydrocarbons followed a porous and permeable pathway to the point where they were trapped. These reservoirs can occur in multiple locations within the same geologic horizon and they can occur in several geologic horizons. In areas where large geologic structures are present hydrocarbon reservoirs can occur one above another in a stacked sequence.

The distribution of multiple hydrocarbon reservoirs within one geologic formation and among multiple geologic formations is illustrative of the potential for CO_2 sequestration (Figure IV.B.5).[106] The eventual number of CO_2 storage reservoirs in West Virginia will be considerably less although the actual number is difficult to predict at the moment. The vast majority of hydrocarbon reservoirs in West Virginia occur above the Silurian section, in the Devonian section and higher, and only about 1 percent of the wells drilled in West Virginia penetrated the Silurian or deeper (see Table IV.B.4). There is potential to sequester captured CO_2 with the potential for multiple seals, either above or below the Devonian-Silurian boundary.

The boundary of a hydrocarbon reservoir is defined by the trap even though we do not know where these boundaries are until the reservoir is discovered, production begins, and the field is developed by drilling more wells. Upon production, the hydrocarbon is removed from the pore space and the reservoir pressure is reduced, but the boundary that defined the limits of the porosity and permeability for a producing reservoir do not change. For sequestration of captured CO_2 in a saline reservoir the extent of the reservoir, its porosity and permeability, are not known with any level of precision. It has yet to be developed. Defining the areal extent of a potential saline reservoir will require some exploration effort, well(s), and seismic providing data in support of computer modeling. Once permitted and upon injection, the CO_2 plume in the reservoir will expand and reservoir pressures will increase. Periodic monitoring of the plume's boundary is required to assure it is migrating in an anticipated manner as the operator gains knowledge of the reservoir.

[106] Data from West Virginia Geological & Economic Survey

Figure IV.B.2: Occurrence of hydrocarbon reservoirs in the West Virginia geologic section

Geologic Systems & Series		Wells	Producing Reservoirs: Oil	O&G	Gas	CBM	Nat Gas Storage	Geologic Unit	Driller's Term
Perm								Dunkard Gp	
Penn	U	2,921	105	54	192	33		Monongahela Gp	
								Conemaugh Gp	
	M							Allegheny Fm	
	L							Pottsville Gp	
Miss	U	1,620	100	64	290		16	Mauch Chunk Gp	Princeton, Ravencliff, Avis, Maxton, Little Lime, Blue Monday
	M	11,738	238	234	476			Greenbrier Gp	Big Lime, Keener, Big Injun
	L	15,314	78	114	300			Price Gp	Squaw, Weir
		6,700	79	74	189			Berea Ss	
Devonian	U	26,684	201	522	1,294		8	Hampshire FM	Gantz, 50',30', Gordon, Gordon Stray, 4th, 5th, Bayard, Speechley Balltown, Bradford, Riley, Benson, Alexander, Elk
								"Chemung Gp"	
								Brallier Fm	
	M	15,324	33	72	207			Harrell Shale	
								Mahantango Fm	
		486	0	27	123			Marcellus Fm	
		5,142	2	8	129			Onondaga Ls	
	L						10	Oriskany Ss	
								Helderberg Gp	
Silurian	U	243	1	0	22			Salina Fm	
								Newburg Ss	
								Williamsport Fm	
	M							McKenzie Fm	
								Rochester Shale	
		574	0	0	12			Keefer Ss	
								Rose Hill Fm	
	L	62	0	0	24			Tuscarora Ss	
Ordovician	U	143						Juniata Fm	
								Oswego FM	
								Reedsville Shale	
								Trenton Gp	
	M	22						Black River Gp	
								St. Paul Gp	St Peter Ss
	L	6	12	6	30			Beekmantown Gp	Rose Run, Copper Ridge
Cambrian	U							Conococheague Fm	
	M							Elbrook Fm	
	L	10						Waynesboro Fm	
								Tomstown Dol	
								Chilhowee Gp	
								Catoctin Fm	
Pre-Cambrian		11						Crystalline Rock	

Confining Unit	Sequestration Target	Organic Shale	Coal –bearing Interval	Basement

Siting of multiple CO_2 storage reservoirs will require regulatory oversight to avoid potential interference of one or more storage reservoirs in the same geologic formation.

IV.B.2.c: Possible Failure of Sequestration

IV.B.2.c.1: Mechanisms of failure

Carbon dioxide could escape from the subsurface through a well casing failure, a well cement failure, a failure at the well head, a well blowout, improperly reworked (workover) wells, improperly abandoned or unmarked wells or a geologic path such as a fault or fractures or a combination. A well failure appears to be one of the more likely causes of a release of CO_2 from underground storage. Pipeline failure presents another possibility of release of CO_2 to the atmosphere. CO_2 pipelines will deliver the CO_2 to the storage field and a field pipeline network will distribute the CO_2 to the injection wells.

Inadvertent release of captured CO_2 can range from minimal and possibly undetectable to catastrophic. The ability to detect leakage from a storage reservoir will depend on the level of resolution of the MVA technology, the thoroughness of the Testing and Monitoring plan developed for the Class VI permit application as well as the MRV plan required by Subpart RR and, most important, the vigilance of the operator. Preventing catastrophic release from pipelines or wells will depend mostly on the quality of the trained personnel operating these facilities.

IV.B.2.c.2: Well failure

Well failure, either leakage behind casing or an actual blowout, is another avenue of release of CO_2 to shallower geologic formations and possibly on to USDWs and eventually the atmosphere or directly to the atmosphere. Class VI regulations provide design goals for CO_2 storage injection wells. Surface casing is to be set below the lower most USDW and cemented back to surface. Long-string casing set from surface through the injection zone is also to be cemented back to surface. Materials used in these wells are to last for the life of the sequestration project. Continuous monitoring of the annulus area between the injection tubing and the long-string casing is required as well as annual evaluations of mechanical integrity (MIT) by wireline logging or other testing method approved by the Director[107].

With continuous monitoring, a change in pressure in the well annulus will alert the operator to a potential leak requiring a closer examination of the well and possibly a well workover. A workover is when a well is opened for repairs and for wells open to high pressure reservoirs this presents the possibility of a well blowout. Carbon dioxide injection wells are high pressure wells. Several blowouts have occurred during operations of West Texas EOR fields from production and injection wells.[108] Release of CO_2 from these blowouts is estimated to range from less than 1 mmcf (million cubic feet) per day to 10 mmcf per day (~53 to 530 metric tons per day).[109] Cause of these blowouts range from corrosion, leaking gaskets, valves left open

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[107] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf

[108] Duncan, I.J., Nicot, J-P., and Choi, J-W, 2008, Risk Assessment for future CO_2 Sequestration Projects Based CO_2 Enhanced Oil Recovery in the U.S. Elsevier. Available online at www.sciencedirect.com

[109] Skinner, L., 2003, CO_2 blowouts: An emerging problem. World Oil, January 2003, p. 38 - 42

or mechanical failure. No injuries or fatalities occurred due to these well blowouts. A carbon dioxide well blowout presents unique challenges. These are high pressure wells and the sudden release of pressure is a high velocity phenomenon that quickly clears out the well. The sharp drop in pressure and gas expansion results in adiabatic cooling. The released CO_2 quickly drops below its triple point providing for the formation of dry ice particles.[110] All of these regulations go to the day-to-day operations of an injection well. But care will be required when one of these well is shut-in and opened up for a workover or an MIT. With anticipated growth of the CO_2 injection business, proper training of CO_2 storage field personnel as well as well workover and well drilling crews is critical for safe operations as well as preventing inadvertent release of CO_2.

Out in the open, it may be difficult for CO_2 to build up to dangerous levels. Monitoring of one of the West Texas well blowouts mentioned above recorded CO_2 levels of approximately 4750 ppm (0.475%) 200 feet away and these accumulations dissipated in about 30 minutes.[111] In Utah, the Crystal Geyser is a CO_2 charged eruption of cold waters via an old wellbore. The well was drilled in 1935 for oil exploration. While this well represents an example of poor oversight of a well permit and improper plugging of an abandoned well, it is a tourist attraction and presents no apparent danger.[112]

Another potential well failure scenario here is leakage through old wells that are improperly plugged and abandoned. An essential aspect of Class VI regulations is corrective action, the second part of the Area of Review and corrective action plan required for application of a Class VI permit. Corrective action is the remediation of old wells that present potential leakage pathways between the CO_2 storage reservoir and the surface. The remediation of these wells can occur as the CO_2 plume grows; this cost can be spread out over time. A potential danger here is that CO_2 may migrate along these pathways and accumulate in confined space, for example the cellar of a near-by house or a structure in or near the storage field. An example of a gas migrating over some distance is a leak from a Kansas natural gas storage field migrated via an old well bore through the vadose zone (shallow subsurface above the water table) into the cellars of buildings in a near-by town.[113] With sufficient accumulation, the natural gas was ignited resulting in several fatalities and destruction of the building. It should be noted that CO_2 is not combustible but it is an asphyxiant in sufficient concentration. Important questions here for sequestration are how many old wells are in the AoR, what is their vintage and how deep were they drilled?

The number of wells drilled in West Virginia total about 145,000 since the earliest recorded effort in the 1840's, although wells with good records total less than 100,000 wells[114]. For those wells with a record (Table IV.B.4), about 15 percent of these wells were drilled through the 1920's. State permitting of wells in West Virginia was instituted in 1929. Over 70 percent of the known wells listed in Table IV.B.4 have been drilled since 1950. Looking at the total possible well count of 145,000 wells, about 47 percent of all wells have been drilled since 1950. In their economic evaluation of the Class VI rules, USEPA estimated that at least 10 percent of the old wells within an AoR will require corrective action and another 15 percent will

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[110] Duncan, I.J., Nicot, J-P., and Choi, J-W, 2008, Risk Assessment for future CO2 Sequestration Projects Based CO_2 Enhanced Oil Recovery in the U.S. Elsevier. Available online at www.sciencedirect.com
[111] Ibid
[112] Crystal Geyser, Wikipedia: http://en.wikipedia.org/wiki/Crystal_Geyser. Retrieved April 18, 2010.
[113] Fredlund, D.F., 2008, The Evolving Regulatory Framework to Govern Carbon Sequestration, presented at the 7th Annual Conference on Carbon Capture & Sequestration, Pittsburg, Pa.
[114] West Virginia Geological & Economic Survey: http://www.wvgs.wvnet.edu/

not have a cement bond log[115]. In the Class VI regulations, it clearly states that corrective action is required for all wells determined to need corrective action[116]. In its economic modeling, USEPA determined this includes all wells that pose a risk and/or lack high quality cementing information[117].

Wells required to be listed in the AoR are all that penetrate the confining zone(s) and operators are required to perform corrective action on all necessary wells within the AoR[118]. This suggests that if a storge reservoir is deep enough in the geologic section, a considerable number of wells may not need to be included in the AoR. As noted earlier, about 1 percent of the wells drilled in West Virginia penetrated the Silurian or deeper horizons (Figure IV.B.2).

Table IV.B.4: Number of wells drilled per decade, average depth drilled and deepest well drilled (2010 decade not listed)

Decade	# Drilled	Avg. Depth (ft)	Deepest (ft)
1860	5	643	1,100
1870	2	1,480	1,480
1880	25	1,572	2,228
1890	1,018	2,273	3,537
1900	3,270	2,448	4,327
1910	7,104	2,360	7,579
1920	6,136	2,254	6,824
1930	4,959	2,542	9,104
1940	8,178	2,841	10,018
1950	8,324	2,752	13,331
1960	11,472	2,754	17,111
1970	11,284	3,198	20,222
1980	16,314	4,122	16,075
1990	8,427	4,196	11,203
2000	12,972	4,267	13,040

[115] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf
[116] Ibid
[117] EPA, 2010, Cost Analysis for the Final GS Rule Appendix A-C PDF, EPA 816-R-10-013, November 2010. Found at: http://water.epa.gov/type/groundwater/uic/class6/upload/uiccostanalysisforthefinalgsruleappendixa-cnov2010.pdf
[118] 118 Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf

Table IV.B.4 above lists some 99,000 wells with a known total depth drilled in West Virginia. As noted earlier there are some 145,000 wells in West Virginia. The difference between the total number of wells drilled and those posted in table IV.B.4 is about 46,000 wells whose locations and total depth are known. They were most likely drilled before 1929 when drillers were not required to secure a permit prior to drilling. The advantage here for the sequestration of captured CO_2 is that the average depth drilled prior to 1930 was less than 2,500 feet. Sequestration of captured CO_2 needs to be at depths greater than 2,500 feet for the CO_2 to be in a supercritical phase that will maximize storage space. This suggests that these 46,000 wells not posted to Table IV.B.4 were drilled to depths less than 2,500 feet. Whether or not they penetrated any seals requiring the storage operator to list them in their AoR and corrective action plan submitted in their Class VI permit application will depend on the geology of that specific area and proper interpretation of the regulations.

IV.B.2.c.3: Faults, Fractures and Displacement

Release of CO_2 to the atmosphere by means other than via a well or pipeline failure is an important consideration. An often cited incident is the loss of life associated with large release of CO_2 from Lake Nyos in Cameroon, Africa. In August of 1986, a large volume of CO_2 that had accumulated at the bottom of the lake was released. This cloud of CO_2 moved downhill from the lake, suffocating about 1,700 people. To the southeast, Lake Monoun had a smaller release resulting in 37 fatalities.[119] Both lakes are in the volcanic region of Cameroon. The CO_2 is from the magma beneath the lakes. This situation is not characteristic of West Virginia or Appalachian Basin geology. In West Virginia, the most likely scenario where CO_2 may accumulate in sufficient concentration to cause asphyxiation would be in confined spaces such as basements.

Other potential migratory pathways for CO_2 are faults that cut to or near the surface and/or fracture patterns. Faults can either be sealing or permeable. They are known to provide the seal to oil & gas reservoirs as well as a migratory pathway to charging a reservoir. Whether or not a fault acts as a seal depends on the fault gouge material and/or the juxtaposition of lithologies on each side of the fault. A fault is also a fracture or series of fractures along which there is displacement. Fractures represent a plane of failure along which there is no displacement and reflect the stresses applied to the formation. The frequency and density of fractures reflects the degrees to which a formation is flexed, bent or curved. All formations in the subsurface are fractured to some extent. Fractures provide pore space and they also provide a migratory pathway, a type of permeability. A combination of faults and fractures can provide a pathway between a reservoir at depth and the surface. Oil seeps at the surface are a known, yet rare, feature that has led to discoveries. Oil Creek, Pennsylvania, is the location of the Drake well discovery, the first successful oil and gas well drilled. Class VI regulations will require identification of "…known or suspected faults and fractures that transect the confining zone(s)…" [40 CFR 146.82(a)(3)(ii)].

Displacement of in situ formation fluids occurs when the injected CO_2 occupies a portion of the pore space previously occupied by formation fluids. Of concern here is that these displaced formation fluids will encounter a fault or leaky wellbore and migrate vertically into

[119] Trying to Tame the Roar of Deadly Lakes, Marguerite Holoway, New York Times, February 27, 2001. Found at: http://www.nytimes.com/2001/02/27/science/trying-to-tame-the-roar-of-deadly-lakes.html?sec=&spon=&partner=permalink&exprod=permalink. Retrieved April 17, 2010

shallower formations, encroach on economic mineral deposits in the same formation or migrate updip and eventually enter shallower groundwater horizons. This displacement is driven by the injection pressures. The primary purpose of the monitoring and testing plan for Class VI regulations and the MRV plan for Subpart RR regulations is to track the CO_2 plume boundary and potential leakage pathways.

IV.B.2.d: Groundwater contamination

IV.B.2.d.1: Regulations Protecting Groundwater

The protection of groundwater throughout a CCS project is vital to the water resources in West Virginia. The current regulations that govern the protection of groundwater include: West Virginia Code, Chapter 22, Article 11 (Water Pollution Control Act) Section 8, Chapter 22 Article 12 (Groundwater Protection Act), and Legislative Rules, Title 47, Series 13 (Underground Injection Control) Sections 12 and 13. The priority for all of these rules is the protection of groundwater.

IV.B.2.d.2: Risks to Groundwater via CCS

Risks to groundwater quality arise from the potential for CO_2 to mobilize organic or inorganic compounds, acidification and contamination by trace compounds in the CO_2 stream, intrusion of native saline groundwater into drinking water aquifers, and the potential for the CO_2 to displace subsurface fluids. The probability of many of these risks occurring may be decreased by a thorough site characterization, sound injection well construction and sufficient monitoring.

IV.B.2.e: Permit Requirements

In addition to the rules and regulations which protect groundwater, there are other factors that CCS permits will utilize to protect groundwater. Gathering geochemical data to establish a baseline for geologic horizons between the reservoir and shallower groundwater horizons is required[120]. Also, a thorough characterization of the injection site and a geological investigation of the injection formations will aid in the identification of potential avenues for groundwater contamination. This is the work that will be presented in the Area of Review and corrective action plan the Testing and Monitoring plan required for application for a Class VI permit. The MRV plan required by Subpart RR requires identification of potential leakage pathways and a methodology for monitoring and detecting any leakage along these potential pathways.[121] Adequate confining zone formations are also necessary to limit the possibility of CO_2 migration into the lower most drinking water aquifer.

Each proposed CCS site should be considered on an individual basis. For instance, the AEP Mountaineer Project has over a thousand feet of confining zone formations between the injection zone and the lower most aquifer. At another site there may only be 500 feet of confining zone formations yet this thinner overall section of impermeable horizons can be equally capable of protecting shallower groundwater horizons. Using the geological

[120] [120] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf

[121] Environmental Protection Agency (EPA-MMR). Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide, 40 CFR Parts 72, 78, and 98. Federal Register, (75)230, p. 75062-64, 75086, 75088, 77235. Retrieved on February 8, 2011, from http://edocket.access.gpo.gov/2010/pdf/2010-29934.pdf

investigation conducted during site characterization, a decision will be made to determine if the formations acting as seals present in the geologic section are sufficient.

IV.B.2.e.1: Groundwater Quality

USDW is an aquifer that "supplies any public water system, or contains a sufficient quantity of ground water to supply a public water system and currently supplies drinking water for human consumption or contains fewer than 10,000 milligrams/liter of total dissolved solids (TDS)"[122]

Table IV.B.5: Classification of Water based on Total Dissolved Solids[123]

Water Classification	TDS milligram per liter
Fresh	0 – 1,000
Brackish	1,000 – 10,000
Saline	10,000 – 100,000
Brine	➢ 100,000

During site characterization, prior to any injection activities, the present USDW groundwater quality at the site must be determined. A minimum of four quarters of monitoring should be completed before injection activities begin. This will enable the storage facility operator to establish a groundwater quality baseline and compare this baseline to test results gathered to the monitoring and testing results gathered after injection has begun and throughout the operations and post-closure site care. A change in the groundwater quality parameters may give an indication of leakage and contamination.

IV.E.2.e.2: CO_2 Injection Well Construction

The primary goal of the Underground Injection Control program is the protection of USDW, i.e. groundwaters. As note earlier, the Class VI injection well rules provide design specifications to meet this goal. Surface casing for Class VI wells is to be set deep enough to place the ground water horizons behind pipe. Surface casing is to be cemented back to surface. Long casing set to total depth or through the injection zone is also to be cemented back to surface casing. Injection of CO_2 will be through tubing set inside the long casing string and tied to a packer set just above the injection zone. The packer set point in the casing will have cement on the backside of the casing. Through the ground water horizons, CO_2 will be transported to the injection zone via tubing set inside the long casing string that is cemented back to surface and is itself set inside the surface casing that is also cemented back to surface casing.[124]

The Class VI rule also requires that the area between the tubing and long-string casing, the annulus, to be filled with a non-corrosive fluid to protect the casing and tubing. Pressure in this annulus area is to be monitored continually for any changes that can indicate a leak. Automatic shut-off valves are to be placed downhole as part of the tubing and at the surface as

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[122] EPA, Glossary if Underground Injection Control Terms. Found at: http://www.epa.gov/r5water/uic/glossary.htm#usdw
[123] Fetter, C.W., 2001, Applied Hydrogeology, Prentice-Hall, Inc., Upper Saddle River, NJ. Table 10.1, p. 386.
[124] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf

part of the wellhead. Injection pressures are to be limited at 90% of fracture gradient pressure[125]. Many states limit injection pressures for Class II wells to 80% of fracture gradient pressures.

Regulations in West Virginia require surface casing for oil & gas wells to be set through the lowest ground water horizon or coal seam, whichever one is deeper.

IV.B.2.f: Induced Seismicity

There are three important pressure gradients in the subsurface: hydrostatic, fracture, and lithostatic. Injection of captured CO_2 for sequestration in saline reservoirs will require pressures in excess of hydrostatic pressure gradient but below those of the fracture pressure gradient. To avoid damaging the storage reservoir or the overlying seal, injection pressures over a longer period of operations will be limited to 90 percent of the fracture pressure at the depth of injection (Figure 4B3). Sequestration of captured CO_2 will result in an increase of subsurface pressures in the storage reservoir.

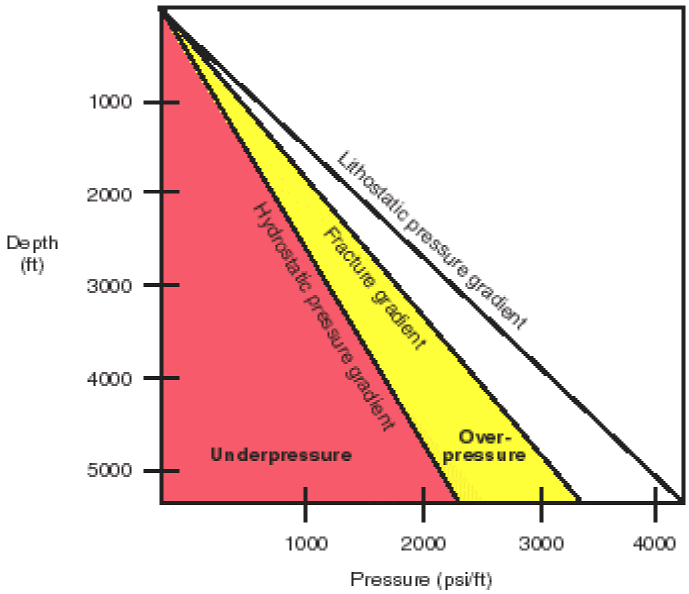
In depleted oil & gas reservoirs, the reservoir pressure will be less than the hydrostatic pressure. Injectivity here may be better than in saline reservoirs due to a higher differential between in situ reservoir pressure and fracture gradient pressure. Hydraulic fracturing of an oil & gas reservoir is a production stimulation technique that momentarily exceeds fracture gradient pressures. It is used in tight natural gas reservoirs to improve well productivity and in oil reservoirs to get production pass near wellbore damage where clays and other fine particulate material is restricting permeability. For situations of induced seismicity however, injection pressures are greater than fracture gradient pressure for either a sustained period of time or in an abnormal subsurface stress environment.

The most widely known incident of induced seismicity occurred at the Rocky Mountain Arsenal near Denver, Colorado between 1962 and 1965. An injection well was drilled to 12,054 feet in the granitic basement rock of the Rocky Mountain front. Formation pressure was measured at 4,133 psi. Injection began at 4,403 barrels per day at 6,033 psi, 1,900 psi over hydrostatic pressure. The fracture gradient illustrated in Figure IV.B.3 is about 0.62 psi per foot, providing a fracture pressure of about 7,473 psi at 12,054 feet. The injection zone was granite and the only available porosity was fracture porosity; matrix or intergranular porosity was absent and the fracture pressure apparently lower than anticipated, if anticipated at all. The first earthquakes occurred within weeks of injection. USGS set up a monitoring system and recorded a total of 710 earthquakes. Injection ceased in 1965. Shortly thereafter final three earthquakes of magnitude 5.0 to 5.2 occurred.[126]

[125] Ibid

[126] Rahn, P.H., 1996, Engineering Geology: An Environmental Approach. Second Edition, Prentice-Hall, Upper Saddle River, N.J., 657 p.

Figure IV.B.3: Subsurface pressure gradients[127]



In Rangely Oil Field, in northwestern Colorado, water flooding of the reservoir for secondary recovery began in 1957. This water flooding triggered earthquakes. A study done by USGS showed that the epicenter of these earthquakes centered in the reservoir and that fluid pressures greater than 4,061 psi in the reservoir "would increase the number of earthquakes from one or two to thirty or forty per month."[128] Subsequently, Stanford University conducted large scale water injections into a fault in Rangely Field that was considered to be near failure. A magnitude 3.1 earthquake was created but the vast majority of induced seismic events were less than a 1 magnitude. Rangely Field is now under active CO_2 injection for tertiary recovery (EOR) without any apparent seismicity problems.[129]

Geomechanical considerations in evaluating a potential CO_2 storage reservoir include:

- Avoid regional tectonic stress near breaking strength of rock
- Avoid potential reservoir where fracture porosity is dominant
- Avoid low permeability reservoirs
- Avoid injection rates that can significantly increase pore pressure over a wide area.

The first two geomechanical considerations listed above are self evident. The next two are somewhat elusive and are tied to rates of injection. Permeability essentially dictates injectivity. High rates of injection require good permeability and/or a thick zone for injection, characteristics unique for each reservoir and injection well. Low permeability means more injection wells to achieve the same rate of injection that fewer wells with better permeability can accomplish. Avoiding increased reservoir pressure over a wide area relates to internal barriers

[127] Found at: http://www.glossary.oilfield.slb.com/DisplayImage.cfm?ID=159
[128] Rahn, P.H., 1996, Engineering Geology: An Environmental Approach. Section Edition, Prentice-Hall, Upper Saddle River, N.J., 657 p.
[129] World Resources Institute (WRI), 2006, CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage. Washington, DC: WRI.

within the reservoir. These barriers can be a change in porosity and/or permeability, faults, or resistance in the displacement of formation fluids, due in part to the first two items. Maintaining a constant rate of injection at this point will increase pressure. Lowering the rate of injection will allow a constant, yet lower, injection pressure. As noted earlier, one way to relieve this situation is to produce the formation waters at some distance from the injection wells, lowering the reservoir pressure and allowing for higher rates of injection. However, handling produced waters adds another level to operations.

Earthquakes that have occurred in West Virginia since 1824 are listed in Table IV.B.6 and illustrated in Figure IV.B.9. The first earthquake recorded by instrument was in 1964; earlier earthquakes, and a couple since 1964, are based on historical records. Earthquake magnitude ranges from a low 0.3 to a high of 4.7, the latter occurring in McDowell County in 1976.

Earthquake magnitude, based on the Richter scale,[130] is logarithmic and is a measure of the energy released by an event. The Modified Mercalli Intensity (MMI) scale[131] and is a measure of the severity of the event and is expressed in Roman numerals.

On the Richter scale, a 3.5 magnitude represent the value below which an earthquake is generally not felt but recorded. Between 3.5 and 5.4, an earthquake is often felt but rarely causes damages. Only 12 of the earthquakes recorded in West Virginia have been greater than 3.5, the earliest occurrence in 1824 based on historical record.

On the MM scale, at a value of III, people inside a building may feel the earthquake but those outside most likely will not. At a value of V, people inside and outside will realize an earthquake has occurred and minor damage will occur such as broken dishes and spilled fluids. The MM scale is only posted for 14 of the 81 earthquakes listed in Table IV.B.6 of which five have a MM value of V or more.

USGS also records seismic events resulting from mining explosions. Between 1997 and 2000, 155 mining explosion events were recorded. None of these events were greater than 3.5. Of the 155 recorded events, 108 were between 2.0 and 2.9 and 45 were between 3.0 and 3.5.[132]

A seismic hazard map for the Central and Eastern United States (CEUS) is presented in Figure IV.B.5. The seismic hazard illustrated here is a 2 percent probability of exceedance of peak ground acceleration in a 50 year period. The map area is dominated by the New Madrid fault zone in southern Missouri where, between December 1811 and February 1812, four earthquakes between 7.0 and 7.5 magnitude occurred, and Charleston, South Carolina where in 1886 a 7.3 magnitude earthquake occurred. As pointed out above, the highest magnitude earthquake in West Virginia was 4.7 in McDowell County in 1976. Contouring on the seismic hazard map indicates higher peak ground acceleration in the southern margin of West Virginia. The majority of earthquakes in West Virginia have occurred in this area (see Figure IV.B.4 and IV.B.5).

The Nagaoka CO_2 injection project in Japan injected 10,400 tons of CO_2 into a saline aquifer at 1,100 meters between 2000 and 2005. Monitoring was conducted between 2005 and

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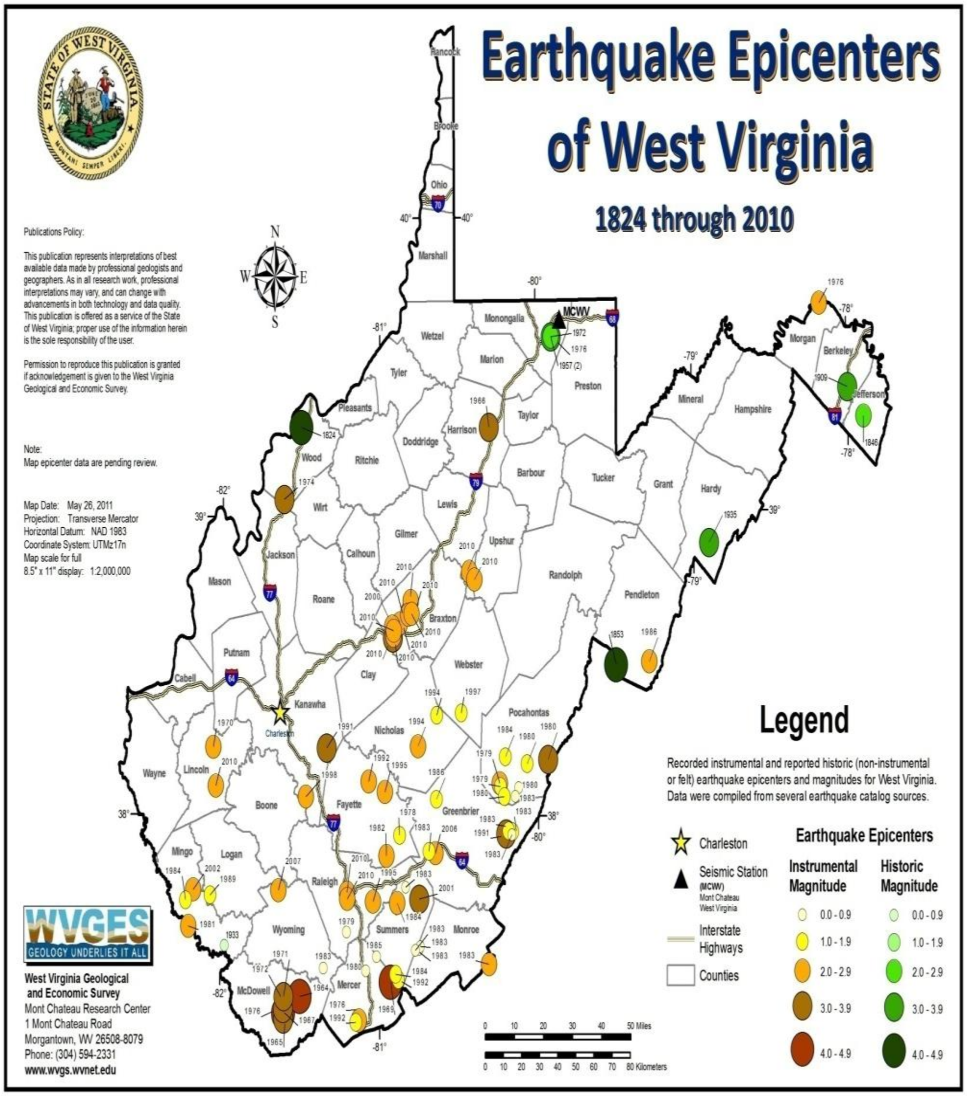
[130] http://crack.seismo.unr.edu/ftp/pub/louie/class/100/magnitude.html
[131] http://crack.seismo.unr.edu/ftp/pub/louie/class/100/mercalli.html
[132] http://earthquake.usgs.gov/earthquakes/eqarchives/mineblast/

2007. The Niigata earthquake of 6.6 magnitude struck in July 2007 and "No CO_2 leakage has been observed."[133]

Figure IV.B.4: Earthquake Epicenters Map of West Virginia

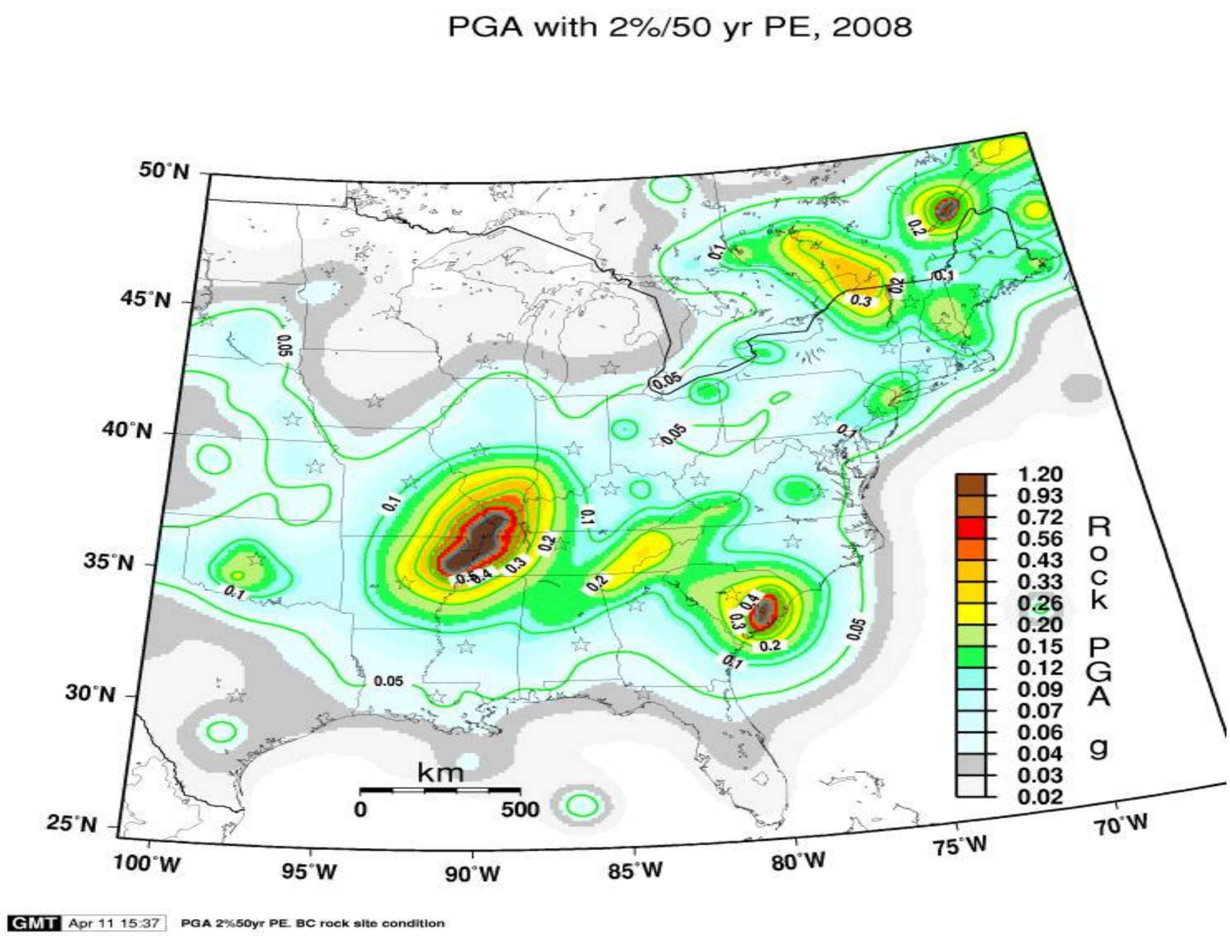


[133] Gassnova, 2010, International CCS Technology Survey. Issue 6. February 2010. Found at: www.gassnova.no

Table IV.B.6: Earthquake data for West Virginia

Num	County	Year	Mag	Record	MMI		Num	County	Year	Mag	Record	MMI
1	Wood	1824	4.1	Hist	IV		42	Summers	1983	0.4	Inst	
2	Jefferson	1846	2.7	Hist	III		43	Monroe	1983	0.7	Inst	
3	Pendleton	1853	4.4	Hist	V-VI		44	Monroe	1983	0.7	Inst	
4	Berkeley	1909	3.6	Hist	V-VI		45	Summers	1983	0.3	Inst	
5	Mingo	1933	0.0	Hist			46	Mingo	1984	1.9	Inst	
6	Hardy	1935	3.3	Hist	IV		47	Summers	1984	1.1	Inst	
7	Monongalia	1957	2.9	Hist	III		48	Summers	1984	2.1	Inst	
8	Monongalia	1957	2.9	Hist	III		49	Pocahontas	1984	1.6	Inst	
9	Morgan	1963	3.6	Hist			50	Mercer	1985	0.8	Inst	
10	McDowell	1964	4.5	Inst			51	Pendleton	1986	2.3	Inst	
11	McDowell	1965	3.5	Inst			52	Greenbrier	1986	1.2	Inst	
12	Harrison	1966	3.1	Inst	IV		53	Logan	1989	1.9	Inst	
13	McDowell	1967	3.5	Inst			54	Greenbrier	1991	3.5	Inst	
14	Mercer	1969	4.6	Inst	VI		55	Kanawha	1991	3.0	Inst	
15	Lincoln	1970	2.8	Inst	IV		56	Mercer	1992	1.4	Inst	
16	McDowell	1971	3.0	Inst			57	Fayette	1992	2.3	Inst	
17	McDowell	1972	3.7	Inst			58	Summers	1992	1.2	Inst	
18	Monongalia	1972	2.9	Hist	III		59	Nicholas	1994	2.1	Inst	
19	Wood	1974	3.8	Inst	V		60	Nicholas	1994	1.7	Inst	
20	Morgan	1976	2.8	Inst			61	Raleigh	1995	2.6	Inst	
21	Monongalia	1976	3.1	Hist	IV		62	Fayette	1995	2.5	Inst	
22	McDowell	1976	4.7	Inst	V		63	Webster	1997	1.8	Inst	
23	Mercer	1976	2.7	Inst			64	Kanawha	1998	2.5	Inst	
24	Fayette	1978	1.6	Inst			65	Braxton	2000	2.5	Inst	
25	Pocahontas	1979	1.6	Inst			66	Summers	2001	3.1	Inst	
26	Pocahontas	1979	2.0	Inst			67	Mingo	2002	2.1	Inst	
27	Raleigh	1979	0.8	Inst			68	Greenbrier	2006	2.6	Inst	
28	Mercer	1980	0.7	Inst			69	Wyoming	2007	2.6	Inst	
29	Pocahontas	1980	1.4	Inst			70	Braxton	2010	3.4	Inst	
30	Pocahontas	1980	1.1	Inst			71	Braxton	2010	2.6	Inst	
31	Pocahontas	1980	3.0	Inst			72	Braxton	2010	2.7	Inst	
32	Pocahontas	1980	0.6	Inst			73	Braxton	2010	2.5	Inst	
33	Mingo	1981	2.5	Inst			74	Braxton	2010	2.6	Inst	
34	Fayette	1982	2.5	Inst			75	Braxton	2010	2.4	Inst	
35	Pocahontas	1983	0.4	Inst			76	Braxton	2010	2.4	Inst	
36	Monroe	1983	2.2	Inst			77	Braxton	2010	2.2	Inst	
37	Greenbrier	1983	1.2	Inst			78	Lewis	2010	2.5	Inst	
38	Greenbrier	1983	1.2	Inst			79	Upshur	2010	2.5	Inst	
39	Greenbrier	1983	0.4	Inst			80	Raleigh	2010	2.4	Inst	
40	Greenbrier	1983	1.6	Inst			81	Raleigh	2010	2.2	Inst	
41	Wyoming	1983	0.6	Inst			82	Lincoln	2010	2.4	Inst	

Figure IV.B.5: USGS CEUS Seismic Hazard Map[134]



[134] http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/ceus/ceus.2pc50.pga.jpg

IV.B.2.g: Pipelines

Table IV.B.7: Pipeline Incidents Statistics for the United States from 1994-2006

Pipelines	Natural Gas		Hazardous Liquids	CO_2
	Transmission	Grid		
Number of Incidents	1,241	1,707	2,048 (1)	18
Number of Fatalities	29	223	24	0
Number of Injuries	112	765	101 (2)	0
Property Damage	$745 million	$780.9 million	$1,006 million	$1.15 million
2006 Mileage (3)	320,073	1,214,439	160,873	3,769

Source: *PHMSA Annual and HL Accident and Gas Incident Reports as of October 15, 2007.*
(1) The reporting criteria changed on February 7, 2002, adding small spills down to five gallons. For continuity with past trending, the data from accidents used in our statistical summary occurring after this date includes only accidents meeting the reporting criteria: accidents with gross loss greater than or equal to 50 barrels; those involving any fatality or injury; fire/explosion not intentionally set; highly volatile liquid releases with gross loss of five or more barrels; or those involving total costs greater than or equal to $50,000.
(2) Does not include 1,851 injuries that required medical treatment reported for the October 1994 accidents that were caused by severe flooding near Houston, Texas.
(3) Transmission mileage includes transmission and gathering miles. Distribution miles include distribution main miles only.

Through 2007, the total miles of CO_2 pipelines was about 0.25 percent of the total natural gas pipeline miles, both transmission and grid pipelines (Table IV.B.7) . Natural gas grid pipelines are the distribution segment of the system, found in areas of higher population density than transmission lines which are cross-country. The higher number of injuries and fatalities for grid natural gas pipeline reflect their proximity to more urban areas. Natural gas pipelines are designed to bring their product from the reservoir to the consumer. The conceptual framework of a CO_2 pipeline network is opposite that of the natural gas pipeline network. Carbon dioxide pipelines will transport their product from a source that may or may not be in an urban area to a storage field located in areas of low population density. The grid portion of the CO_2 pipeline network will be in the storage field or among the storage fields. The captured CO_2 will be removed from the 'market' area and returned to the field.

To accomplish the task of significantly reducing CO_2 emissions envisioned for CCS technology, the present CO_2 pipeline network will be greatly expanded. Simple modeling studies done to date suggest a pipeline network of between 6,000 and 36,000 miles transporting as much as 54 Gt of captured CO_2.[135] The actual CO_2 pipeline network could be double the mileage estimate of these studies, even triple yet still be less that the overall network of that for hazardous liquids and still only a fraction of the natural gas pipeline network. Unlike natural gas, CO_2 is not flammable and does not represent an explosive risk, an important point that should reduce the level of risk associated with these pipelines. Carbon dioxide will be transported under higher pressures than that for natural gas to maintain the supercritical or dense

[135] Carbon Sequestration & Storage: Developing a Transportation Infrastructure. Prepared for the INGAA Foundation, Inc. byICF International. February 2009. Available at: http://www.ingaa.org/cms/31/7306/7626/8230.aspx.
Also: Dooley, JJ, RT Dahowski, and CL Davidson. "Comparing Existing Pipeline Networks with the Potential Scale of Future U.S. CO_2 Pipeline Networks." Presented at 9th International Conference on Greenhouse Gas Control Technologies on November 16-18, 2008, at the Omni Shoreham Hotel in Washington DC. Available at: http://www.sciencedirect.com/science/article/B984K-4W0SFYG-7D/2/a0db295a18b4fe6099846c2ab2738bb0.

phase state. A common accident for pipelines is a puncture due to construction activity. The sudden release of pressure due to puncture of a CO_2 pipeline will be 'explosive' in character but not flammable. There is considerable potential of harm for those in the immediate area. However, the potential for injuries associated with a much longer CO_2 pipeline network should not appreciably increase the possibility for incidents and an increase in fatalities even less. This will depend on urban proximity to the greatly expanded CO_2 pipeline network yet the non-flammable nature of CO_2 should keep the potential for fatalities lower than that for natural gas pipeline incidents.

In testimony before the House Subcommittee on Energy and the Environment, Ian Duncan of the Texas Bureau of Economic Geology stated "It has been suggested in the literature that the incident rate CO_2 pipelines can be estimated from that for natural gas pipelines. USDOT statistics recorded ten incidents of CO_2 pipelines failures. The DOT data suggest that these incidents were caused by: relief valve failure (four incidents); weld, gasket, valve packing failure (three); corrosion (two); and outside force (one). Similar DOT statistics for a very large data set of natural gas pipelines in the US showed the reasons for failure as: outside force, including damage by contractors, farmers and utility workers (35%); corrosion (32%); other, such as vandalism, train derailment and improper operation of manual valves (17%); weld and pipe failures (13%); and operator error (3%). There is good reason to believe that the rate of incidents (rupture, puncture, etc.) for CO_2 and natural gas pipelines should be the same if CO_2 sequestration is implemented on a large scale. It is important to note that even if the rates of incidents for CO_2 and natural gas pipelines begin to look the same in the future; my judgment is that the risk will still be lower for CO_2 pipelines (a conclusion that appears to be increasingly supported by governmental reports and academic studies). I also believe that the risk from rupture of CO_2 pipelines is the largest risk facing a future CO_2 sequestration industry. If this conclusion proves correct then this places strong bounds on the risks of geologic CO_2 sequestration. Ultimately the risk from pipelines depends on: siting of the pipelines (risks are site specific); operation of the pipelines to minimize possible corrosion (particularly the current industry focus on keeping the water levels in the CO_2 below saturation); and implementation of effective risk management and mitigation plans."[136] Note that in the testimony, there is only one incident of outside force rupturing a CO_2 pipeline while this category accounts for 35 percent of natural gas pipeline failures. Although it may be more rural relative to the natural gas pipeline network, expanding the CO_2 pipeline network will expose it to more opportunities of outside force rupturing.

The Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) has had, since 1988, oversight authority of transportation of CO_2 by pipeline.[137] Carbon dioxide is non-combustible and non-toxic. It is heavier than air. When concentrated it can pool near the ground, displacing oxygen. With time it dissipates, forming a cloud. Because of these properties and the fact that CO_2 is transported as a compressed gas and/or in high concentrations, it is classified as a hazardous material and subject to the Hazardous Material Transportation Laws and DOT's implementing laws. Pursuant to

[136] Ian Duncan, 2009, Regarding The Future of Coal under Climate Legislation; Carbon Sequestration Risks, Opportunities, and Learning from the CO_2-EOR Industry. Testimony before the The U.S. House Committee on Energy and Commerce, Subcommittee on Energy and the Environment, March 10, 2009.

[137] Krista L. Edwards, Deputy Administrator, Pipeline and Hazardous Materials Safety Administration, Department of Transportation, testimony before the Committee on Energy and Natural Resources, United States Senate, January 31, 2007.

legislation establishing DOT's oversight of CO_2 pipeline, the Department extended its existing hazardous liquids pipeline rules to CO_2 pipeline operations.[138]

PHMSA works closely with certain state agencies to provide oversight of CO_2 pipeline network. Their "integrity management regulations, which currently apply to transmission pipelines (liquid and gas), require operators to conduct risk assessments of the condition of their pipelines; develop and implement risk control measures to remedy safety problems, worst first; and evaluate and report on program progress and effectiveness. Under integrity management programs, operators are identifying and repairing pipeline defects before they grow to failure, producing steady declines in the numbers of serious incidents."[139]

PHMSA "operates five regional pipeline safety offices and is authorized to employ 111 inspection and enforcement professionals for fiscal year 2008. In addition to compliance monitoring and enforcement, PHMSA's regional offices respond to and investigate pipeline incidents and participate in the development of pipeline safety rules and technical standards. Our regional offices also work closely with PHMSA's State program partners, which employ approximately 400 pipeline inspectors and directly oversee the largest share of the U.S. pipeline network, including most intrastate pipelines. Under our Congressionally-authorized Community Assistance and Technical Services (CATS) program, PHMSA's regional offices provide safety-focused community outreach and education. With the current wave of pipeline expansion, and increasing commercial and residential development around existing pipelines, the CATS program is serving a vital role in educating the public about pipeline safety and encouraging risk-informed land use planning and safe excavation practices."[140]

The WVDEP or another agency may want to coordinate CO_2 pipeline oversight efforts with the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA). PHMSA already has oversight relationships with states where CO_2 pipelines are in operation.

IV.B.3: Identify geologic sequestration monitoring sites to assess the short-term and long-term impact of carbon dioxide sequestration - §22-11A-6(h)(5)

Injection of captured CO_2 in a supercritical or dense phase is a high pressure operation that increases the pressure in the storage reservoir for some radial distance from the injection well. It is essential to monitor two fundamental boundaries during and following injection of captured CO_2: the plume boundary itself and pressure boundary associated with the plume. These two boundaries will be monitored during injection operations, post-injection site care and long-term stewardship time periods for each CO_2 storage reservoir. A basic goal is to know the location of the edge of the plume and associated pressure front and its impact on displaced formation fluids. Surface and subsurface monitoring provides the necessary data needed to demonstrate that the CO_2 plume is not migrating beyond the boundaries of its trap and presenting

[138] Ibid

[139] Krista L. Edwards, Deputy Administrator, Pipeline and Hazardous Materials Safety Administration, Department of Transportation, testimony before the Committee on Energy and Natural Resources, United States Senate, January 31, 2007.

[140] Ibid

an endangerment[141] situation, either to groundwaters (underground source of drinking waters (USDW)), the atmosphere, ecosystems and to human health.

A Testing and Monitoring plan (aka MVA program) designed to track the plume and pressure boundaries is one of five plans required to be submitted for application of a Class VI injection permit[142]. A Class VI permit entails compliance with Subpart RR and development of a Monitoring, Reporting and Verification (MRV) plan .[143]

IV.B.3.a: Monitoring, Verification and Accounting (MVA)

A basis for a MVA program will be established prior to site characterization because baseline measurements, a key component for a successful MVA programs, will be collected during site characterization. A MVA program will be unique to each CO_2 storage reservoir and will reflect the geologic characteristics present in the subsurface. The details of any particular MVA program, the selection of technology and location of monitoring sites is the decision of the operator with the approval of the regulatory oversight board.

Monitoring of the injected CO_2 will be done in the subsurface and at the surface. The most obvious location for monitoring is in well bores. Well bores are data points providing direct measurement of the storage reservoir, the seal or cap rock and overlying stratigraphic horizons including groundwater aquifers. Aside from injection wells, monitoring wells located at some distance from injection wells can provide observation points to monitor storage reservoir pressure as well as formation water/CO_2 plume chemistry. Monitoring wells in proximity to the underlying CO_2 plume, reaching a total depth (TD) above the reservoir seal, are also important points of observation and measurement. These monitoring wells may also serve a dual purpose in monitoring groundwaters overlying the CO_2 plume. Surface measurements will be conducted at surface facility locations including delivery point of captured CO_2, point of separation to storage field pipeline system, injection wells, and monitoring wells and within the Area of Review (AoR). Class VI regulations require monitoring wells to test groundwaters and formations waters above the confining zone as well as direct and indirect measurements from the CO_2 reservoir[144]. Direct measurements are from wells drilled into the storage reservoir and indirect measurements are geophysical techniques. The Director may also require near surface and/or surface monitoring under Class VI rules but this will be required under Subpart RR[145].

A wide range of technology is available to monitor, verify and account for the character and lateral extent of a CO_2 plume in the subsurface (Table IV.B.8). Application of this

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[141] As proposed, an operator can be released from obligations under a Class VI injection permit when non-endangerment can be demonstrated. Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf

[142] Ibid

[143] Environmental Protection Agency (EPA-MMR). Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide, 40 CFR Parts 72, 78, and 98. Federal Register, (75)230, p. 75062-64, 75086, 75088, 77235. Retrieved on February 8, 2011, from http://edocket.access.gpo.gov/2010/pdf/2010-29934.pdf

[144] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf

[145] Environmental Protection Agency (EPA-MMR). Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide, 40 CFR Parts 72, 78, and 98. Federal Register, (75)230, p. 75062-64, 75086, 75088, 77235. Retrieved on February 8, 2011, from http://edocket.access.gpo.gov/2010/pdf/2010-29934.pdf

technology begins during site characterization when baseline measurements are established. This information is critical in providing recognition and assessment of data variances from baseline measurements.[146]

Technologies are available for all aspects of captured CO_2 injection operations. Geophysical methods at the surface which includes 2-D and 3-D seismic that if repeated over consistent time intervals can provide 4-D seismic coverage over a broad geographic coverage of subsurface stratigraphy. In the wellbore, geophysical or wireline logging tools can provide subsurface measurements of formation fluids and the rock material that can be tied to and calibrate the surface seismic data. Wireline logs are run after a well is drilled before casing is set (i.e. openhole well logs) and also after casing is set. Cased-hole logging is done to verify quality of the cement job binding the casing to the surrounding rock and to detect leaks or potential paths of migration behind casing. Vertical seismic profiles (VSP) or cross-well seismic is data gathered from wellbores that can be tied to surface seismic data. Cores or sidewall cores are taken when wells are drilled and provide direct measurement of the porosity and permeability of the storage reservoir, cap rock or seal and other formations sampled.

[146] EPA, 2008, Vulnerability Evaluation Framework for Geologic Sequestration of Carbon Dioxide. Technical Support Document. EPA430-R-08-009

Table IV.B.8: Technologies for MVA.

Monitoring, Verification, Accounting (MVA) Technologies

Geologic Storage	Monitoring, Verification, and Accounting (MVA)	Simulation and Risk Assessment
Wellbore Technologies - Wireline logging (geophysical logging): Electrical (resistivity), density, neutron, Gamma Ray (GR), Spontaneous Potential (SP), Sonic, Nuclear Magnetic Resonance (NMR), Borehole Imaging, Temperature, Cement Bond, - Drillstem Test (DST) - Whole core, sidewall core - Formation fluid sampling (reservoir, seal, others) - Pressure fall-off test, injectivity tests - Wellhead, Annulus & Downhole Pressure - Downhole Temperature - Aero-magnetics (old wells)	Subsurface Monitoring Technologies: - Seismic: 2-D, 3-D, 4-D, Vertical Seismic Profile (VSP), Cross-Well, Micro. - Electromagnetic Surveys - Electrical resistance tomography (ERT) - Gravity, Microgravity - Tiltmeter - Water Quality Analysis - Wireline logging - Wellhead, Annulus & Downhole Pressure - Downhole Temperature - Core analysis (new monitoring wells) - Soil gas monitoring	Thermal & Hydrologic Modeling - MODFLOW, GFLOW
Mitigation/Remediation Technologies - Pump and treat formation fluids - Pump and treat groundwater	Remote Sensing & Near Surface Monitoring Technologies - InSAR - Air photography - Soil gas sampling - Groundwater monitoring (geochemical analysis of samples taken from wells) - Advanced Water Quality Analysis: inorganics, organics, isotopes, total organic & inorganic carbon - 2-D seismic (shallow)	Geochemical Effects of CO_2 Injection - PFLOTRAN, STOMP, TOUGHREACT, VIP Reservoir
Fluid Flow, Pressure and Water Management - MODFLOW, GFLOW - Eclipse, GEM-GHG, NUFT, NFFLOW-FRACFEN - Production of reservoir formation fluids - Treatment/disposal of prod formation fluids	Atmospheric Monitoring Technologies - Eddy Covariance - CO_2 detectors - LIDAR & laser systems	Geomechanical Effects of CO_2 Injection - TOUGH-FLAC, GMI-SFIB, ABCUS
Geochemical Impacts -PFLOTRAN, STOMP, TOUGHREACT, VIP Reservoir - Groundwater analysis - Reservoir formation fluid analysis - Other formation fluid analysis (seal, overlying units)	Design of Intelligent Monitoring Networks and Monitoring Protocols	Biologic Modeling
Geomechanical Impacts -TOUGH-FLAC, GMI-SFIB, ABCUS - Rock mechanic analysis (core studies)		Risk Assessment Identification and Quantification

Source: NETL Best Practices for: Monitoring, Verification, and Accounting of CO_2 Stored in Deep Geologic Formations, January 2009 (Tables 5-1 & 3-1)

Class VI injection well rules will require continuous monitoring of injection pressures, rate and injected volumes of the injection well[147]. This provides for continuous mechanical integrity testing (MIT) however an annual examination of the mechanical integrity of the injection well by a wireline logging technique is also required although the Director may require other techniques at certain intervals[148]. Subsurface pressures can also be acquired from non-injection wells with downhole pressure sensors.

Near surface soil gas monitoring and/or surface air monitoring can be included in the Monitoring and Testing plan submitted for a Class VI permit. It may also be included per agreement between the Director and the applicant for approval of the Class VI permit[149]. Once issued a Class VI permit, per Subpart RR regulations, the operator is required to submit a Monitoring, Reporting and Verification (MRV) plan within 180 days (see Table IV.B.1) which will require monitoring of potential surface leakage. The Testing and Monitoring plan can be the basis for development of the MRV plan[150]. Surface monitoring will include leak detection from surface equipment used for injection, soil gas analyses and ambient monitoring of the near surface atmosphere.

IV.B.3.b: Legislative and Regulatory Activity

Several states have passed legislation regarding carbon capture and sequestration. With respect to monitoring, each piece of legislation only provides general direction to the appropriate regulatory body to develop more specific requirements for monitoring and verification. Location of specific monitoring sites will depend upon the question to be answered and the technology selected. Regulations will provide the questions and the site operator will select the technology with the understanding that they, the operator, are responsible for providing a suitable and acceptable answer. It must be recognized by all involved that available technology for recording geologic information at depth has some limitations regarding degrees of accuracy and/or level of resolution.

Washington and North Dakota have developed specific CO_2 sequestration regulations in response to legislation. Washington's legislation only required that the governor "develop policy recommendations on how the state can achieve the greenhouse gasses emissions reductions goals established under section 3 of" of the bill[151]. The Department of Ecology, with the help of a working group, established rules for CO_2 injection projects[152]. These rules require that a Permit Application include, among other items, information regarding "Location of all pertinent surface facilities, including atmospheric monitoring within the boundary of the project", a "leak detection and monitoring plan using subsurface measurements to monitor movement of the CO_2 plume both within and to detect migration outside of the permitted geologic containment

[147] Federal Requirements Under the Underground Injection Control (FR-UIC) Program for CO_2 Geologic Sequestration (GS) Wells (40 CFR Parts 124, 144, 145, 146, and 147). *Federal Register*, (75)237, December 10, 2010, p. 72248, 77230, 77234-35, 77244-46, 77288. Retrieved on February 8, 2011, from http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf
[148] Ibid
[149] Ibid
[150] Environmental Protection Agency (EPA-MMR). Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide, 40 CFR Parts 72, 78, and 98. Federal Register, (75)230, p. 75062-64, 75086, 75088, 77235. Retrieved on February 8, 2011, from http://edocket.access.gpo.gov/2010/pdf/2010-29934.pdf
[151] Engrossed Substitute Senate Bill 6001. Found at: : http://apps.leg.wa.gov/documents/billdocs/2007-08/Pdf/Bills/Session%20Law%202007/6001-S.SL.pdf. Retrieved: February 23, 2010
[152] Norman, D.K. and J. Stormon, 2007, White Paper: Feasibility of Using Geologic Formations to Sequester Carbon Dioxide (CO_2), Department of Ecology. Found at: http://www.ecy.wa.gov/climatechange/docs/co2sequestrationfinal_082807.pdf. Retrieved February 23, 2010.

system." (WAC 173-218-115)[153]. This leak detection and monitoring plan includes "monitoring of pressure responses and other appropriate information immediately above caprock of the geologic containment system." One of the terms and conditions attached to a permit is that "The monitoring program shall include observations in the monitoring zone(s) that can identify migration to aquifers as close stratigraphically to the geologic containment system as practicable."(WAC 173-218-115). Specific items to monitor as specified in the regulations are:

- Characterization of injected fluids
- Continuous recording of injection pressure, flow rate and volume
- Continuous recording of pressure on annulus between tubing and long string casing
- Monitoring zone leak detection
- Sufficient monitoring to confirm the spatial distribution of the CO_2 in the subsurface

Each specific item listed above to be monitored suggests a monitoring location but the regulations avoid suggesting or mentioning specific locations. Washington's regulations are comprehensive but not prescriptive; they provide the potential operation a good sense of what is expected for safe operations of a captured CO_2 storage field and what questions need to be answered. It will be up to the operator to select suitable technology that will record the necessary information with which to answer the questions.

North Dakota legislation (Senate Bill No. 2095) requires the industrial commission to determine before a permit is issued "that the storage operator will establish monitoring facilities and protocols . . . ." The commission is also required to "take action that carbon dioxide does not escape from a storage facility." This was accomplished when regulations became effective in April 2010[154]. Essentially, the North Dakota regulations follow those developed by Washington and later published by the EPA in the Federal Register in December 2010. Although not proscriptive in the technology selected and applied, the goal to assure that the CO_2 injected remains in the reservoir is apparent in the regulations. It will be the responsibility of the operator to comply and fulfill the expectations of these regulations.

Montana legislation (Senate Bill No. 498)[155] specifies that captured CO_2 injection permits include requirements for applicable pressure and fluid chemistry data as well as monitoring and verification. One specific request is an "adequate baseline monitoring of drinking water wells within 1 mile of the perimeter of the geologic storage reservoir." One mile from the perimeter of the geologic storage reservoir could be quite a distance from the CO_2 plume on initial injection.

Louisiana legislation (House Bill No. 661) provides the commissioner of conservation the duties and powers to promulgate rules and regulations requiring "interested person to place monitoring equipment of a type approved by the commissioner . . . ," and that monitoring will be regulated by rules developed by the commissioner.[156]

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[153] Washington UIC Program, Dept. of Ecology, Found at: http://www.ecy.wa.gov/biblio/wac173218.html
[154] ND Geologic Storage of Carbon Dioxide: https.//www.dmr.nd.gov/oilgas.rules/rulebook.pdf
[155] Montana, 61st Legislature, Senate Bill No 498, found at: http://data.opi.mt.gov/bills/2009/billpdf/SB0498.pdf
[156] Louisiana, Regular Session, 2009, House Bill No. 661, found at: http://www.louisianalawblog.com/uploads/file/HB-661(1).pdf

Each of the legislatures from Washington, Montana, North Dakota and Louisiana provided direction to their respective executive departments charged with captured CO_2 sequestration regarding overall monitoring goals. The specifics are left to the regulator to develop as Washington's Department of Ecology did for that state. Washington's regulations lists monitoring goals regarding tracking the CO_2 plume and detection for leakage yet deferred to the prospective operator the selection of specific monitoring technology with which to fulfill regulatory requirements.

At the Federal level, USEPA published the UIC Class VI regulations in the Federal register in December 2010. At the same time they also published Subpart RR, an update to their mandatory greenhouse gas reporting rule that will cover CO_2 sequestration operations. Both provide direction on the location for monitoring the CO_2 storage operations. Under Class VI rules monitoring wells will be required to provide "periodic monitoring of groundwater quality and geochemical changes above the confining zone" as well as "direct methods in the injection zone"[157]. Class VI rules also require indirect monitoring, geophysical techniques, of the CO_2 plume. The injection well is also a critical monitoring location under Class VI rules. As noted above, near surface and surface monitoring can be included in the Monitoring and Testing plan for Class VI permit application but it will be required to be addressed in the Monitoring, Reporting and Verification (MRV) plan under Subpart RR. Both Class VI and Subpart RR regulations specify that the CO_2 plume, groundwaters and the area above the confining zone, near surface and surface areas will be monitored by monitoring wells, indirect geophysical methods, soil sampling and surface air monitoring. The actual location of these wells and sampling sites and selection of the technologies used are left to the operation.

IV.B.4: Assess the feasibility of carbon dioxide sequestration in West Virginia and the characteristics of areas within the state where carbon dioxide could be sequestered- §22-11A-6(h)(6)

IV.B.4.a: The kinds of geological formations which might work.

Feasibility for carbon dioxide sequestration in West Virginia is a reflection of the geology of West Virginia. West Virginia is, essentially, located entirely within the extents of the Appalachian Basin. This is a foreland basin[158] oriented along a general northeast-southwest axis, extending from north central Tennessee to central New York. Structurally, the strata within the basin become deeper to the southeast where it is bounded by the Allegheny Structural Front [159](Figure IV.B.7). Within West Virginia, this general trend is broken into two northeast-southwest trending structural features, the Rome Trough and the Upland Horst (Figure IV.B.6). In Figure IV.B.6, the Rome Trough is illustrated by the tight, northeast-southwest trending, structure contours while the Upland Horst is illustrated by the southeast-northwest trending structure contours. The Allegheny Structural Front (labeled in Figure IV.B.7) is the southeast boundary of the Upland Horst. In southern West Virginia the Rome Trough is structurally

[157] Environmental Protection Agency (EPA-MMR). Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide, 40 CFR Parts 72, 78, and 98. Federal Register, (75)230, p. 75062-64, 75086, 75088, 77235. Retrieved on February 8, 2011, from http://edocket.access.gpo.gov/2010/pdf/2010-29934.pdf8

[158] Wickstrom, L.H. et al., 2005, Characterization of Geologic Sequestration Opportunities in the MRCSP Region, Phase I Task Report Period of Performance: October 2003-September 2005, DOE/NETL DE-PS26-05NT42255

[159] Roen, J.B., and B.J. Walker, 1996, The Atlas of Major Appalachian Gas Plays, West Virginia Geological and Economic Survey, Publication V-25.

deeper to the Upland Horst but both features merge to a common depth in northeastern West Virginia. The sedimentary section ranges from 8,000 feet to more than 20,000 feet in the Rome Trough and in the northeastern corner of the state.

Clastics, carbonates, and coal seams comprise the stratigraphic section found in West Virginia (Figure IV.B.2). The two dominant carbonate sedimentary rocks are limestones and dolomites. Sandstones and shales are clastic rocks. Sandstones and carbonates are the dominant reservoir rocks for oil and gas with shale commonly providing the seal. Sometimes a tight (very low to essentially no permeability) carbonate rock will act as the seal trapping oil and gas within a reservoir. Long known as a source rock as well as an excellent cap rock for hydrocarbon reservoirs, organic rich shales have been recognized, as early as the 1970s, as a reservoir from which natural gas can be produced. A trap rock or seal represents a sharp reduction in permeability blocking further migration of fluids or gas.

All four of these sedimentary rock types can provide suitable conditions for sequestration of captured carbon dioxide. Sandstones, carbonates and unmineable coal seams are recognized as potential reservoir rocks while shale or a tight carbonate can provide the seal, or confining barrier. MRCSP provided an estimate of storage potential for shales in their Phase I report.[160] In their Sequestration Atlas, NETL did not provide an estimate of storage potential for shales.[161] The ability of shale to act as a sequestration reservoir is still under study.

The Midwest Regional Carbon Sequestration Partnership (MRCSP), one of the seven regional partnerships created by DOE/NETL, encompasses West Virginia and most of the states overlying the Appalachian Basin. The MRCSP conducted an evaluation of sequestration potential within the area of the partnership during Phase I of their project period.

The stratigraphic section present under West Virginia is illustrated in Figure IV.B.2. Formations with sequestration potential are illustrated in blue and formations that can provide a seal or act as a confining unit are illustrated in lime green.

Sequestration potential is present in the (also see Figure IV.B.2):

- Upper Devonian Sandstones
- Lower Devonian Oriskany Sandstone
- Lower Silurian Sandstones
- Ordovician St. Peter Sandstone
- Cambrian Rose Run Sandstone & Copper Ridge Dolomite
- Basal Rome Trough Sandstone

Confining units are present above each formation with sequestration potential presenting multiple barriers to migration. At the top of the stratigraphic section are the Pennsylvanian coals.

It should be pointed out that West Virginia has a naturally occurring CO_2 reservoir. Indian Creek field is located in Kanawha County, West Virginia. The reservoir is the Lower Silurian Tuscarora Sandstone. As is the case with all the Tuscarora fields, it is located on an anticline (the northeast plunging nose of the Warfield anticline). Porosity is developed in the

[160] Wickstrom, L.H. et al., 2005, Characterization of Geologic Sequestration Opportunities in the MRCSP Region, Phase I Task Report Period of Performance: October 2003-September 2005, DOE/NETL DE-PS26-05NT42255
[161] NETL, 2008, Carbon Sequestration Atlas of the United States and Canada, second edition. Found at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasII/index.html

fractures associated with the structure. The Warfield anticline is asymmetric and water is reported downdip to the southeast of the productive wells. Apparently porosity pinches out downdip to the northwest and also off the northeast plunging nose of the anticline.

More than 30 wells were drilled in the field between 1973 and 1987. Food grade carbon dioxide along with methane are produced; the gas is reported to be more than 60% carbon dioxide.[162,163,164] Approximately 20 bcfg (billion cubic feet of gas) has been reported as produced from 1981 through 1992.[165]

IV.B.4.b: The extent and location of potentially feasible formations

The occurrence of oil & gas production in West Virginia illustrates the general extent of potentially feasible geologic formations for sequestration (Figure IV.B.7). Oil and gas fields are primarily found northwest of the Allegheny Structural Front to the Ohio River (Figure IV.B.7) and this will be the general area within which saline storage potential will be found.

It should be noted here that the Appalachian Power Company Mountaineer Plant along the Ohio River in New Haven (Mason County), West Virginia recently began injection of captured CO_2 into the Rose Run sandstone and Copper Ridge dolomite. A seal is provided by the Beekmantown dolomite which immediately overlies the Rose Run[166].

IV.B.4.c: Ability to assess specific CO_2 storage project feasibility

The purpose for any CO_2 storage field is to sequester the CO_2 captured from the source(s) with whom they have a contract. The operator of a storage field believes they have a certain amount of storage volume that will accommodate injection over a period of time. The source(s) hopes the storage field will be in operation over the life of their plant. Why does the storage field operator believe that they have sufficient storage capacity? Why was that location selected? Where was the necessary information found?

The ability to assess any specific project location and potential depends on the quality of the initial data available or that can be acquired. NATCARB data published in the Carbon Sequestration Atlas of the United States and Canada suggest a range of storage potential for the various states. These values represent a storage resource that needs to be proven. When an exploration well discovers oil and/or gas and establishes production, a portion of the oil and gas resource has been proven. Carbon sequestration reverses the process in a sense. Here, the resource is potential storage capacity (i.e. pore space or porosity) representing the ability to inject captured carbon dioxide over a period of time. This potential needs to be proven, a process that begins with regional evaluation of geologic potential that leads towards selection of a specific site for further characterization. But why select any particular site for CO_2 storage operations?

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162 Hamak, J.E., and Sigler, Stella, 1991, Analyses of natural gases, 1986-1990: U.S. Bureau of Mines Information Circular IC 9301, 315 p.

163 Hamak, J.E., and Gage, B.D., 1992, Analyses of natural gases, 1991: U.S. Bureau of Mines Information Circular IC 9318, 97 p.

164 Jenden, P.D., Drazan, D.J., and Kaplan, I.R., 1993, Mixing of thermogenic natural gases in northern Appalachian basin: American Association of Petroleum Geologists Bulletin, v. 77, p. 980-998.

165 Avary, K.L., 1996, Play Sts: The Lower Silurian Tuscarora Sandstone Fractured Anticlinal Play: *in* Roen, J.B. and Walker, B.J., eds., The Atlas of Major Appalachian Gas Plays: West Virginia Geological and Economic Survey, Volume V-25, p. 151-155.

166 Mountaineer Injection Well Geological Report,

Figure IV.B.6: Structure contours on top of crystalline basement rock

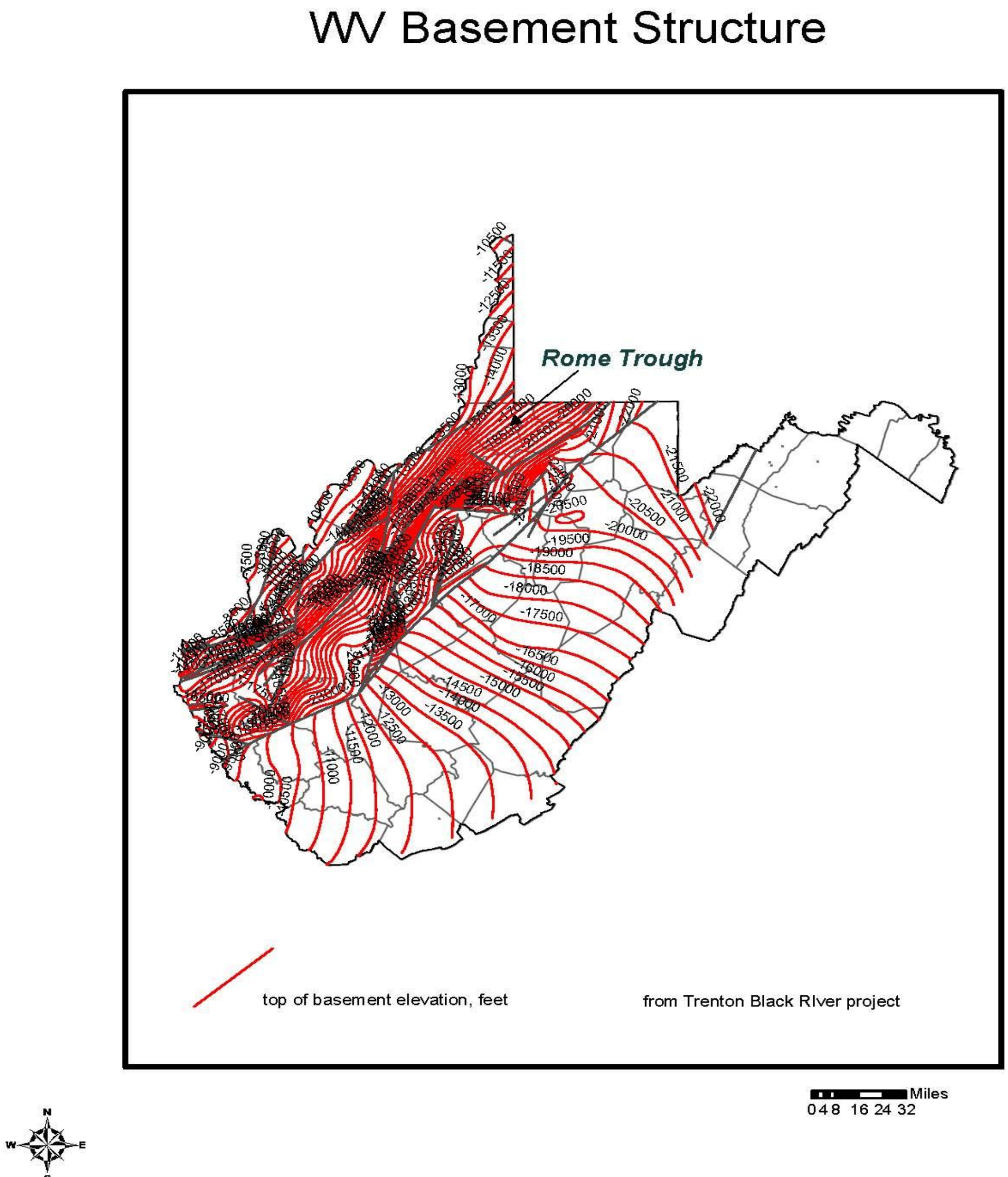
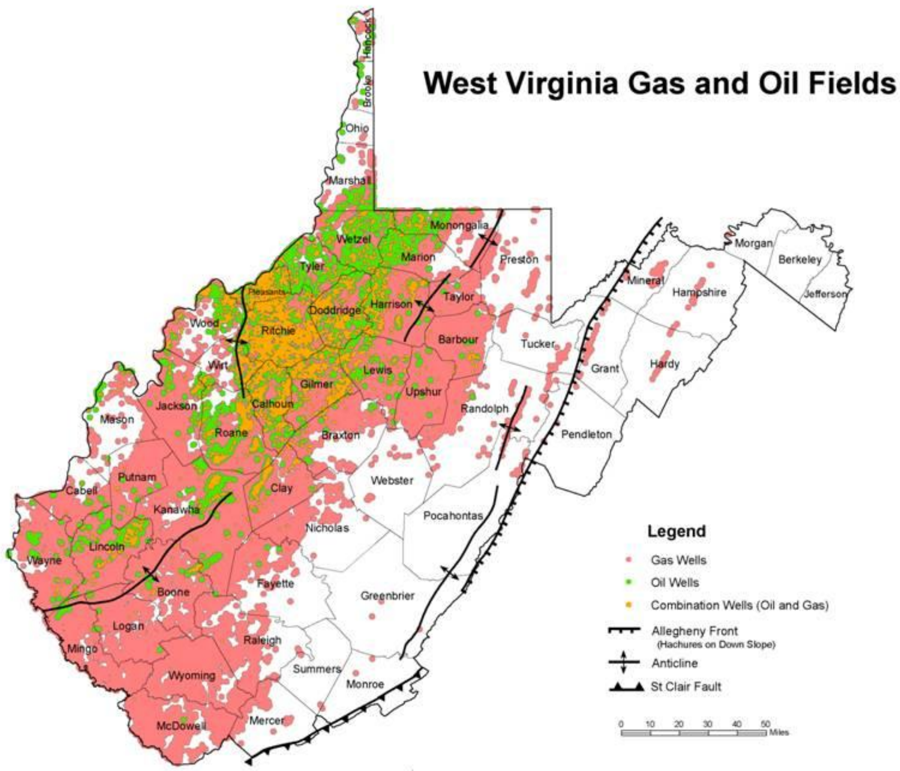


Figure IV.B.7: Distribution of oil & gas fields in West Virginia



We know oil and gas fields have storage capacity but these potential storage fields represent between 9 and 27 percent (see 2010 data in Table 4E10) of the overall storage potential in West Virginia. Saline reservoirs represent the largest potential, between 67 and 88 percent of total potential in West Virginia, for sequestration of captured carbon dioxide. Oil and gas exploration did its best to avoid discovering water. Unless it occurs above a producing field, saline horizons are not well drilled and there will be less data available. Any potential storage field developer may or may not have a need to sequester a specific volume of captured CO_2. They may only be conducting an opportunity search. Emission sources though will have specific needs that must be met. An initial assessment will provide some perspective on the size of potential storage fields. Publicly available data and information will be critical for initial evaluation of storage potential, selecting a site for further site characterization. Sources of this information will be the state geological survey, publications in professional journals and academia. With this data, a prospective storage field developer should be able to determine prospective areas, how much territory will be required to cover the extent of a potential plume of sequestered CO_2 and what additional data needs to be acquired

IV.B.5: Assess the potential carbon dioxide sequestration capacity in this state-§22-11A-6(h)(8)

IV.B.5.a: Existing storage potential estimates

As noted above, the potential storage capacity for sequestering captured CO_2 is a resource value. Like any other natural resource, such as oil & gas or coal, actual storage capacity has to be proven. For oil & gas or coal, this involves drilling a well to gain an actual measurement of the resource and establishing a proved reserve. With production, a better understanding of an oil & gas reservoir is gained over time. Having a better understanding of the reservoirs potential, proved reserve values are sometimes increased. A proved reserve, while a more certain value, is also smaller than the value attached to the resource. For CO_2 sequestration, proving the resource potential will be done by site characterization and injection during field operations will further refine the understanding of a reservoir's storage capacity.

The Midwest Regional Carbon Sequestration Partnership (MRCSP) is one of seven regional partnerships assembled by DOE/NETL to evaluate, test and demonstrate carbon sequestration potential across the United States. States within the MRCSP are Michigan, Ohio, West Virginia, Maryland, Pennsylvania, New York, the northeastern half of Indiana and the eastern half of Kentucky. Geologic horizons or formations (Figure IV.B.2) considered for sequestration potential by the Midwest Regional Carbon Sequestration Partnership are:[167]

- Upper Devonian: Hampshire Group (Berea Sandstone)
Greenland Gap Group
Rallier Formation
- Lower Devonian: Oriskany Sandstone*
- Lower Silurian: Newburg Sandstone
Keefer Sandstone
Brassfield Formation
Cabot Head Formation
Tuscarora Sandstone* (Medina Group)
- Upper Ordovician: Black River Group
St. Peter Sandstone
- Upper Cambrian: Rose Run Sandstone*
Copper Ridge Dolomite
- Lower Cambrian: Un-named Basal Sandstone*
(below Rome Formation)

At the top of the stratigraphic section in West Virginia are the coal bearing strata:

- Pennsylvanian*: Monongahela Group
Conemaugh Group
Allegheny Group
Pottsville Group
Kanawha Group
New River Group
Pocahontas Formation

The sequestration potential for the organic rich shales was also evaluated:

[167] Wickstrom, L.H. et al., 2005, Characterization of Geologic Sequestration Opportunities in the MRCSP Region, Phase I Task Report Period of Performance: October 2003-September 2005, DOE/NETL DE-PS26-05NT42255
Ibid

- Devonian*: Ohio Shale
  Java Formation
  West Falls Formation
  Sonyea Formation
  Genesee/Harrell Formation
  Marcellus Formation

The MRCSP estimated the potential storage volume for each state within the partnership[168] (for West Virginia an * designates which units above contribute to the estimates in Table IV.B.9). Volumetric capacity for saline and oil & gas reservoirs was calculated at 10% efficiency. In a volume of sedimentary rock, the intergranular space is known as porosity, the pore space. This pore space represents some portion of the rock volume expressed as a percentage and is occupied by fluids, water or oil, or gases. Storage efficiency with respect to captured CO_2 is the percentage of pore space that may be occupied by the injected CO_2. A 10% storage efficiency means that the sequestered CO_2 will only occupy 10% of the pore space for that particular oil & gas reservoir or saline formation. While an organic rich shale will have some storage capacity within its fracture system, a much larger volume of captured CO_2 may be stored by adsorption onto the clay minerals and organic matter. Storage capacity for the coals is also an adsorption process. There are several factors that can impact sequestration potential for organic rich shales and coals. In their Phase I report, the MRCSP calculated the potential storage for shales and unmineable coal seams with a 10% efficiency as applied to saline and oil & gas reservoirs. It should be noted that only unmineable coal seams are considered in these estimates of storage potential in coal for captured CO_2.

Assumptions on storage efficiencies are important. The total volume of CO_2 to be sequestered in a saline reservoir is product of the total area (A_t), gross height (h_g), total porosity (Φ_{tot}), density (ρ) of the CO_2 at reservoir temperature and pressure and the storage efficiency (E_{saline}) for saline formations as set out in equation 1 below[169]. Detailed modeling of geologic data from oil & gas reservoirs provided the basis to derive storage efficiencies for saline reservoirs. This work was done by the Energy and Environmental Research Center (EERC) at the University of North Dakota and funded by the International Energy Agency (IEA) and NETL[170].

$$G_{CO2} = A_t \, h_g \, \Phi_{tot} \, \rho \; E_{saline} \qquad (1)$$

The storage potentials posted in the 3rd edition of the Atlas represent statistical analysis of the data presented by the IEA study. The storage efficiency values used by NETL in the 3rd edition of the Atlas are based on "documented ranges derived from oil and gas reservoirs and numerical simulations" done in the IEA study[171]. The range of storage efficiency for clastic, limestone and dolomite sedimentary rocks is 0.4 to 5.5 percent, the values posted in Table IV.B.15 below. Storage efficiency for oil & gas reservoirs is based in EOR experience while for

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[168] Wickstrom, L.H. et al., 2005, Characterization of Geologic Sequestration Opportunities in the MRCSP Region, Phase I Task Report Period of Performance: October 2003-September 2005, DOE/NETL DE-PS26-05NT42255
[169] NETL, 2010, Carbon Sequestration Atlas of the United States and Canada. Found at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIII/index.html
[170] IEA Greenhouse Gas R&D Programme (IES GHG), 2009, Development of Storage Coefficientrs for CO_2 Storge in Deep Saline Formations, 2009/13, November 2009
[171] Ibid

unmineable coal seams storage efficiency does not reflect the fraction of pore space occupied but the degree that CO_2 can saturate coal[172]. Storage efficiency factors represent a P_{10}, P_{50}, and P_{90} probability range.

Table IV.B.9: Potential Storage Capacity for Captured CO_2 in West Virginia

	Shales	O & G	Coal	Saline	Total	Storage Efficiency
MRCSP	19,000	600	110	41,100	60,810	10%
NETL (2008) (low)	-	1,353	177	3,343	4,873	1%
NETL (2008) (high)	-	1,353	177	13,463	14,994	4%
NETL (2010) (low)		1,830	320	4,480	6,630	0.4%
NETL (2010) (high)		1,830	500	17,930	20,260	5.5%

All values are in million metric tons. Storage efficiency is discussed in the text.

Except for oil & gas reservoirs, the area over which these storage estimates apply is the geographic extent of each horizon evaluated. The saline efficiency factors are applicable at the regional/basin scale. The IEA study presented some saline storage efficiency factors for site specific situations, depending on lithology and depositional environment that range from 4.24 to 14.92 percent[173]. As noted earlier, these potential storge values represent a resource that needs to be proven which will be accomplished to a large degree by the characterization process. Like any other resource such as coal or oil, while proving a resource provides a more reliable reserve value upon which to base economic decisions, this reserve value is usually a reduction of the earlier resource value.

As required in the Energy Independence and Security Act (EISA) of 2007, USGS will assess the onshore storage potential for captured CO_2.[174]

IV.B.5.b: Refinements of estimates: Information needed

Storage capacity in any potential reservoir is a function of porosity or void space found within any suitable rock. Permeability connects the pore space and allows flow through the reservoir. Good permeability is essential for injectivity, good porosity is essential for storage capacity, and good storage efficiency is necessary to maximize the use of available pore space.

[172] Ibid

[173] Ibid 162; see Table 13 on p. 62.

[174] USGS, 2009, Development of Probabilistic Assessment Methodology for Evaluation of Carbon Dioxide Storage, OFR 2009-1035.

This available porosity and permeability that defines a reservoir has a top and bottom (height), a net portion of the whole (gross height) formation or stratigraphic interval within which it occurs. This available porosity and permeability of the reservoir is not uniformly distributed over the areal extend of the formation or stratigraphic interval within which it occurs. This is also referred to as reservoir architecture which reflects depositional environment and post-depositional modifications. Estimates of storage potential presented in this report assume an areal distribution of porosity over the extent of the prospective formation or stratigraphic interval; they represent regional/basinal estimates. That is why these resource values need to be proven. It will take time, money and acquisition of suitable data.

Pore space is not empty. In oil & gas reservoirs there is some percentage of oil, gas and water in each pore space and below the oil/water contact the pore space is 100 percent water with some amount of dissolved solids. Pore space in saline formations or reservoirs will be fully occupied by water with some amount of dissolved solids. Knowledge of the constituent fluids in a prospective storage reservoir will be essential to reservoir modeling for site characterization and developing an MVA program. This critical reservoir information is provided by a combination of drilling data, core data, wireline or geophysical log data and seismic data will help to extrapolate this information across the geographic area of the potential storage field. As pointed out by the USEPA in the Class VI rules, this information will be used to generate the Area of Review (AoR).

IV.B.5.c. How much CO_2 needs to be stored: Amount generated by a power plant

A 1,000 MW bituminous pulverized coal power plant, operating at 85 percent capacity and capturing 90 percent of its carbon dioxide emissions will produce 6.24 million tonnes of carbon dioxide in a year.[175] On a daily basis for sequestration, this is about 100,000 barrels of CO_2 per day for injection. In 2009, West Virginia oil production averaged about 155,000 barrels of oil per month or 5,000 barrels of oil per day.[176] If this 1,000 MW plant has a 50 year project life, then about 1.8 billion barrels of CO_2 will need to be sequestered. In the world of oil & gas production, this is a giant field (>500 million barrels recoverable) and they are not commonly found. Granted, saline traps may be more numerous than oil & gas traps but we do not know this for sure, it will require an exploration effort.

In the third edition of the Sequestration Atlas, 27 sources in West Virginia emit about 99.2 million tonnes (580 million barrels) of CO_2 per year (Table 4E11). The table was assembled by the MRCSP. With an estimate storage resource potential between 6,630 and 20,260 million tonnes, West Virginia has, based on 90 percent capture, between 74 and 227 years of injectivity.

It is interesting to note that the Big Sandy power plant is across the Big Sandy River from West Virginia in Kentucky and including this power plant on a list of emissions for West Virginia highlights an important consideration regarding CCS. Emissions do not respect political boundaries and neither will CO_2 plumes in the subsurface. There are several power plants on both sides of the Ohio River. West Virginia can only address what it can control but it will be important to work with adjoining states.

[175] MIT, 2007, The Future of Coal. Found at: http://web.mit.edu/coal/
[176] EIA: http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFPWV1&f=M

Table IV.B.10: List of emission sources with annual emissions in metric tons.

Plant / Facility	Company	Industry Sector	County	Annual CO_2 Emissions[1]	Annual CO_2 Emissions[2]
John E Amos	Appalachian Power Co.	Power	Putnam	15,231.230	15,822,530
Harrison	Monongahela Power Co.	Power	Harrison	12,862,820	11,937,920
Mt. Storm	Dominion Virginia Power	Power	Grant	10,961,580	10,246,110
Mitchell	Ohio Power Co.	Power	Marshall	7,973,820	8,253,660
Mountaineer	Appalachian Power Co.	Power	Mason	7,663,480	8,645,590
Pleasants	Monongahela Power Co.	Power	Pleasants	7,224,740	7,488,590
Fort Martin	Monongahela Power Co.	Power	Monongahela	6,895,640	6,350,400
Big Sandy[3]	Kentucky Power Co.	Power	Lawrence	6,048,400	6,167,550
Phil Sporn	Central Operating Co.	Power	Mason	5,383,580	4,816,800
Weirton Steel	Weirton Steel Corp.	Iron & Steel	Weirton	3,957,880	3,957,880
Kammer	Ohio Power Co.	Power	Marshall	3,449,410	3,226,580
Mingo Country CBM	CONSOL	Gas Processing	Varney	2,836,420	2,836,420
Kanawha River	Appalachian Power Co.	Power	Kanawha	2,338,270	1,973,100
Albright	Monongahela Power Co.	Power	Preston	1,760,340	1,150,230
Willow Island	Monongahela Power Co.	Power	Pleasants	1,367,590	649,210
Martinsburg	Capital Cement Corp.	Cement	Martinsburg	831,020	831,020
Grant Town Power Plant	Edison Mission Power	Power	Marion	790,850	863,870
Rivesville	Monongahela Power Co.	Power	Marion	608,430	217,350
Natrium Plant	PPG Industries Inc.	Power	Marshall	593,320	934,770
Kenova	Mark West Hydrocarbon Inc.	Gas Processing	Wayne	498,350	498,350
Copley Run		Gas Processing	Lewis	491,278	491,278
Hastings	Dominion Resources	Gas Processing	Wetzel	486,190	486,190
North Branch	Dominion Virginia Power	Power	Grant	485,310	702,240
Morgantown Energy Facility	Morgantown Energy Assoc.	Power	Monongahela	448,840	584,140
Alloy Steam Station	West Virginia Alloys, Inc.	Power	Fayette	297,990	140,320
West Union		Gas Processing	Doddridge	200,973	-
Schultz		Gas Processing	Pleasants	111,653	-
Ergon Refining		Refining	Newell	110,780	110,780
Cobb[4]	Mark West Hydrocarbon Inc.	Gas Processing	Kanawha	101,290	101,290
Total Annual Emissions				102,011,474	99,173,290

1 – 2nd Edition of Atlas
2 – 3rd Edition of Atlas
3 – Kentucky Power Co. Big Sandy plant is on the Kentucky side of the Big Sandy River
4 – Cobb Gas Processing Plant listed twice in 2nd Edition, corrected for 3rd Edition

IV.B.5.d: The area needed for storage

Estimating the area needed for a storage field is difficult. Because of the buoyancy of CO_2 relative to saline formation fluids, standard simple model used in modeling CO_2 injection displays an inverted cone with the accumulation of the CO_2 gathering at the top of the reservoir against the seal. This simple model assumes a homogeneous reservoir that ignores geologic variability of reservoir architecture.

In this simple model the areal extent of the CO_2 plume at the top of the reservoir is much larger than at the bottom of the reservoir and will require more surface acreage to secure the rights to the pore space for the top of the plume than the base of the plume. Any reservoir will have internal permeability barriers that will compartmentalize the porous and permeable space available for storage. If this simple model included several permeable barriers acting as internal traps within the reservoir then the surface area of the plume would be reduced. Such modeling done by Advanced Resources International suggests that the plume area could be reduced by 60% from that of the simple model.[177]

An important consideration here is that the stratigraphic section present in West Virginia has multiple horizons with storage potential. Utilizing each of these horizons for sequestration of captured CO_2 will create a stacking of storage reservoirs, one above the other or overlapping to some extent. This is true for oil and gas fields, especially for structurally trapped hydrocarbons. Discoveries on structure are first made in the shallow reservoir but upon drilling deeper, oil and gas is often encountered in lower reservoirs. Stacked and/or overlapping reservoirs will help reduce the areal extent of sequestered CO_2 plumes has measured at the surface. Important considerations here will be the location of surface facilities, wells and monitoring sites as these plumes expand with injection.

The Carbon Sequestration Working Group (CSWG) in Wyoming did some modeling utilizing a value of so many million tonnes of CO_2 sequestered per square mile.[178]. Modeling done by the Wyoming State Geological Survey suggested a plume area factor of 0.15 mi^2 per million tonnes CO_2 injected (6.67 Mt/mi^2). The CSWG cited a NETL value of 0.75 mi^2 per million tonnes of CO_2 injected (1.33 Mt/mi^2) but they thought that this was too conservative for their purposes and adopted a value of 0.15 mi^2 per million tonnes injected, an 80 percent reduction in area needed to cover the plume in the subsurface. As noted above, modeling done by ARI shows that multiple permeability barriers within the reservoir can reduce the areal extend of a CO_2 plume by 60 percent. How many tonnes of CO_2 will be stored per square mile will end up being formation specific. However, until these hard values are determined, the above mentioned values may be used to do simple spreadsheet model estimates and evaluate prospective areas for further site characterization. Which value or what value to use will be up to whoever is conducting the evaluation.

$$G_{CO2} / A = h \, \Phi \, \rho \, E_{saline} \qquad (2)$$

[177] Kuuskraa, V., 2009, Using Reservoir Architecture to Maximize CO2 Storage Capacity at SECARB's Mississippi Test Site; presented at GHGT-9, Washington, D.C., November 2009.

[178] Report and Recommendations of The Carbon sequestration Working Group to the Joint Minerals, Business and Economic Development Committee and the Joint Judicial Committee of the Wyoming State Legislature, September, 2009. Found at: http://deq.state.wy.us/out/downloads/1%20FinalReport081909.pdf

Looking at a simple storage scenario with one well injecting into a reservoir covering 25 mi^2: with a storage factor of 0.15 mi^2 per 1Mt this storage reservoir will hold 166.67 Mt but only 33.3 Mt with a storage factor of 0.75 mi^2 per million tonnes. Equation 2 above states that the volume of sequestered CO_2 per area equals the product of height, porosity, density of CO_2 and storage efficiency for saline reservoirs. Equation 2 also shows that height, porosity, density of CO_2 and storage efficiency for saline reservoirs is inversely proportional to area. The difference between the two storage factors, 0.15 mi^2 per one million metric tons (1Mt) per or 0.75 mi^2 per Mt, can reflect either a change in porosity (Φ in equation 2) or change in height (h) or thickness of the injection-storage interval or a change in storage efficiency (E_{saline}) or in a combination of any of these factors. For example, if porosity is 15 percent, storage efficiency is 10 percent and the density of CO_2 at 6,000 feet is 933.6 tons per acre-foot, then sequestering 166.67 million tonnes (Mt) of CO_2 within an area of 25 mi^2 (0.15mi^2/Mt) will require a reservoir height of 744 feet, to sequester 33.3 Mt of CO_2 (0.75mi^2/Mt) the reservoir height needs to be 149 feet. If storage efficiency is reduced to 5 percent, reservoir height increases to 1,488 feet (0.15mi^2/Mt) and 297 feet (0.75mi^2/Mt) respectively. Sequestering 166.67 Mt of captured CO_2 with a storage factor of 0.75 mi^2/Mt will require 125 mi^2 of land leases to secure pore space rights.

The ability to sequester captured CO_2 for three different sized plants in a storage field covering 25 mi^2 is illustrated in Table IV.B.11 below. Only the Albright plant can be accommodated by this particular storage field. And this will be close as the reservoir is at its limit for this plant. Both the John Amos and Phil Sporn plants will have to find other reservoirs or another larger reservoir to accommodate their sequestration needs.

Table IV.B.11: Years of injection for emissions of three plants**.**

Plant Name	**Power MW**	**90% CO_2 Emissions Mt/yr**	**CO_2 Emission 30 yr Plant Life Mt**	**Years injection – 25 mi^2 area**	
				[0.15mi^2/Mt] [166Mt]	**[0.75mi^2/Mt] [33 Mt]**
John Amos	2,932	14.2	426	11.7	2.3
Phil Sporn	1,105	4.3	129	38.7	7.7
Albright	292	1.0	30	166.7	33.3

IV.B.5.e: Data needed for better estimates of potential storage capacity

The challenge here is to estimate the amount of square area that will need to be characterized and permitted in order to secure the rights to the pore space for sequestration over the life of a particular project. The position and stability of a three dimensional plume of CO_2 in the subsurface is related back to two dimensional surface area. The best set of data that any CO_2 storage field operator will have for their reservoir will be at the end of operations when injection is completed and the field is decommissioned. At this point in time, one knows for certain how much CO_2 is sequestered and its areal extent. Thirty or fifty years earlier, the level of certainty for both was much less yet projections were made based on modeling available geologic data on hand at the time. This early information was presented to a regulatory body in order to gain a permit to develop and operate a CO_2 storage field.

Essential data necessary for better storage calculations is porosity, permeability, height of injection interval, areal extend of porosity and permeability and how much pore space will the

CO_2 occupy, the efficiency factor as well as geochemical data on formation fluids. As noted earlier, initial data sources will include the USGS and state geological databases, academic studies and publications, and professional publications. Saline formations are estimated to provide for most of the sequestration, between 67 and 88 percent of total estimated sequestration capacity in West Virginia, yet these formations will have the smallest database. In West Virginia, about half of the potential saline storage formations occur below the Lower Devonian Oriskany Sandstone (Figure IV.B.2) yet only 1 percent of the oil & gas wells drilled in West Virginia penetrated these horizons. For saline formations this data will be more difficult to assemble. Except for the CO_2 efficiency factor, oil & gas reservoirs will provide most of the data for modeling saline reservoirs.

Key information is porosity and permeability. Is there sufficient reservoir present to accommodate the volume of captured CO_2 to be sequestered? Porosity can be calculated from well logs but permeability measurement requires a rock sample, either a whole core or sidewall core. If this information doesn't exist then a well will have to be drilled which will require a permit and the right to drill on that acreage. Is it worth drilling the well before committing to site full characterization? Is there any seismic data to support further work on the prospect? An important step here is moving from initial assessment to site characterization as this step will require an investment of millions to tens of millions of dollars. Making an investment in a subsurface resource requires sufficient data and information to assure investors that the risk is acceptable, that there is an acceptable probability that the project will go forward. Due to the exploration nature of saline storage, there will be a probability that the initial site selected for characterization will prove not to be sufficient for intended sequestration operations and another site from the list of prospects will have to be selected for full site characterization. It should also be noted that early movers in developing CO_2 storage fields will be the first to secure favorable structural locations in the subsurface based on current well control knowledge. As CO_2 storage development progresses with increasing demand for storage space, the favorable locations will have been taken and new locations will be a bit more elusive.

It is widely considered that a CO_2 storage field developer will have to secure the rights to utilize subsurface pore space for sequestration per state regulation. Securing this right is a strategic decision upon which to make an investment. How much area to secure to establish rights to pore space is problematic because the actual extent of the subsurface saline reservoir is unknown. A right of access will have to be established for site characterization to provide access for seismic data acquisition, drilling of a well or wells and initial MVA activity. Some seismic Vibroseis coverage can be acquired along public highways. Knowing how much area for which to secure pore space rights at the beginning of the process of developing a CO_2 storage field may come down to individual "rule of thumb," the storage factor (see Table IV.B.11). The ability to assess economic potential for CO_2 sequestration and proceed with site characterization and securing the rights to subsurface pore space over a broad areal extent will depend on the quality of geologic data available for initial assessment of subsurface potential.

Reservoir assumptions impact estimates of potential storage capacity. Dominant reservoir modeling to date assumes an open reservoir where the CO_2 pressure front does not encounter a boundary resulting in increasing injection pressures. The formations utilized for injection at Sleipner and at In Salah are considered open reservoirs. While some consider most reservoirs closed, many believe reservoirs in general have more open than closed characteristics.[179] A solution to maintaining constant injection pressure is the co-production of formation waters during injection, providing pressure relief and creating an open reservoir. The Wyoming State Geological Survey (WSGS) modeled co-production of formation waters during sequestration operations.[180] WSGS model was able to render about 80 percent of the produced water potable, injecting the remaining 20 percent into the subsurface. They noted this potable water has agricultural or residential potential or can possibly be released to streams or rivers. Co-production of formation waters adds another level to operations requiring additional capital, raising operating expenses and requiring additional permits.

IV.B.5.f: Risks Assessment

The capture, transportation, and geologic storage of carbon dioxide present environmental and safety risks. What these risks are, and whether they are manageable, are critical questions for the future of carbon sequestration. Identification and estimation of the magnitude of the various risks associated with pipeline transportation and sequestration of captured CO_2 is also important to site selection, permitting, and liability issues. Not understanding and managing the risks of carbon dioxide transportation and geologic storage could invite failure of an environmentally critical program.

What is risk? USEPA defines risk as "the chance of harmful effects to human health or to ecological systems resulting from exposure to an environmental stressor." A stressor is "any physical, chemical, or biological entity that can induce an adverse response. Stressors may adversely affect specific natural resources or entire ecosystems, including plants and animals, as well as the environment with which they interact." [181]

Risk has been defined in the context of CO_2 sequestration as:

> "two factors - the probability (frequency) of a specified hazardous event and the severity of the consequences from that event. Risk can be defined as the product of these two factors:
>
> Risk = Frequency x Consequences
>
> Thus, one can have the same level of risk for a frequent event with a low level of damage as for a rare event with a very high level of damage. Therefore, in developing a risk assessment, one must evaluate both frequency and potential damage from an event."[182]

Risk assessment has been described as "the process leading to the characterization of a risk."[183] A risk assessment typically has four components: hazard identification, dose response

[179] Economides, M.J. and Ehlig-Economides, C.A., 2009, Sequestering Carbon Dioxide in a Closed Underground Volume, SPE Paper 124430, Presented at SPE ATCE meeting in New Orleans, October 2009.
Dooley, J.J. and Davidson, C.L., 2010, A Brief Technical Critique of Ehlig-Economides and Economides 2010: "Sequestering Carbno Dioxide in a Closed Underground Volume", PPNL-19249

[180] Surdam, R.C., Zunsheng, J., Stauffer, P., and Miller, T., 2010, An integrated strategy for carbon management combining geological CO_2 sequestration, displaced fluid production, and water treatment. Challenges in Geologic Resource Development No. 8, Wyoming State Geological Survey.

[181] www.epa.gov/risk/basicinformation.htm Reference to or quotation from particular sources should not be taken as approval of the views expressed by the source.

[182] Risk Assessment and Management For Long-Term Storage of CO_2 In Geologic Formations, Dawn Deel, Kanwal Mahajan, Christopher R. Mahoney, Howard G. McIlvried, and Rameshwar D. Srivastava. Systemic, Cybernetics and Informatics volume 5 number one, page 79.

[183] Footnote 1, page 15, Science and Decisions: Advancing Risk Assessment (2009), The National Academies Press.

assessment, exposure assessment, and risk characterization. Risk assessments can range from qualitative, through semi-quantitative, to highly quantitative. The literature of risk assessment is enormous.

The field of risk assessment continues to evolve. The first major work on risk assessment the so-called Red Book was published in 1983.[184] In 2006 the federal Office of Management and Budget proposed a Risk Assessment Bulletin to guide federal agencies in risk assessments.[185] Recently the National Research Council was asked by USEPA to form a committee to develop scientific and technical recommendations to improve the risk analysis used by USEPA. The result was a publication titled "Science and Decisions: Advancing Risk Assessment."

The value of risk assessment continues to be debated.[186] A principal concern with risk assessment is scientific uncertainty. The Red Book addressed this concern as follows:

> When scientific uncertainty is encountered in the risk assessment process, inferential bridges are needed to allow the process to continue. The Committee has defined the points in the risk assessment where such inferences must be made as *components*. The judgments made by the scientists/risk assessor for each component of the risk assessment often entail a choice among several scientifically plausible options; the Committee has designated these *inference options*.

Despite the issues raised by risk assessments they are the tool most commonly used in analyzing risk. Understanding risk assessments, and their strengths and limitations is a necessary element of determining the feasibility of carbon dioxide transportation and geologic storage.[187]

IV.B.5.f.1: Risk Assessment Specific to Carbon Dioxide Transportation and Sequestration

Risk assessment is already occurring in the field of carbon dioxide transportation and sequestration. The literature on this subject is already significant, and is rapidly expanding. There are two sources of information and data to inform risk assessments about carbon dioxide: first, the existing experience in transportation and use of carbon dioxide for enhanced oil recovery (EOR); and second, the experience in analogous areas such as the transportation and storage of natural gas.[188]

IV.B.5.f.2: Pipelines

There are presently about 3,800 miles of carbon dioxide pipelines in operation in the United States.[189] These pipelines are regulated by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration. See generally 49 USC 5101 et seq. and

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[184] "Risk Assessment in the Federal Government: Managing the Process". National Research Council. 1983. National Academy Press. This is sometimes known as the Red Book.

[185] Scientific Review Of the Proposed Risk Assessment Bulletin From the Office Of Management And Budget, Committee to Review the 0MB Risk Assessment Bulletin National Research Council (2007).

[186] An Overview of "Science and Decisions: Advancing Risk Assessment", Jonathan Levy et al., Volume 17, Issue 1, Risk in Perspective, Harvard Center for Risk Analysis. www.hcra.harvard.edu

[187] Risk assessment must be accompanied by the companion disciplines of risk management and risk communication. These companion disciplines are equally important.

[188] See generally, "Comparison of risks from carbon dioxide and natural gas pipelines", A. McGillivray & J Wilday, Health and Safety Laboratory, Harpur Hill, Buxton, Derbyshire, SK17 9JN. 2009.

[189] Kadnar, J.O. Experience in the CO2 Transportation via Pipeline, in CCS Web Conference on CO_2 Transport, Health And Safety Issues, [US Department of Transportation], 2008 International Energy Agency: Paris.

49 USC 60101 *et. seq*. Department of Transportation regulations in some circumstances require that a pipeline project perform a risk assessment. 49 CFR Part 195.

The principal risks in the pipeline transportation of carbon dioxide are leaks or ruptures.[190] These can occur in various ways. Once a leak or rupture occurs its impact depends on the material released, the magnitude of the release, the local conditions, and the immediate population in the vicinity of the leak. While carbon dioxide is not flammable, it is heavier than air and can settle into depressions creating a risk of asphyxiation.[191] An unfortunate example of this occurred at Lake Nyos in Cameroon[192] yet there is evidence that accumulations of CO_2 will disperse in a safe and reasonable amount of time.[193] It is a risk that must be recognized.

An example of a risk assessment for a carbon dioxide pipeline is found in Appendix E Carbon Dioxide Pipeline Risk Analysis HECA Project Site Kern County, California, Prepared for Hydrogen Energy International LLC, May 19, 2009.[194] This particular pipeline is about 4 miles long and is for EOR.

This particular risk assessment begins by defining risk as “a combination of the probability of a scenario versus the severity of its consequences.” [p. 1-3]. The risk analysis is described as a semi-quantitative analysis based on historical data. It identifies scenarios with adverse consequences that may occur, estimates potential consequences, estimates the likelihood of occurrence, and evaluates the risk.

The risk analysis develops frequencies of occurrence estimates and potential consequences, and establishes a risk index. Particular kinds of failure are considered. Perhaps the most significant part of the analysis is a consideration of the historical failure rate of carbon dioxide pipelines. [p.2-1, Table IV.B.4]. The accident/spill records of carbon dioxide pipelines were obtained from data provided by the Office of Pipeline Safety of the DOT. A historical failure rate for carbon dioxide pipelines was created. Air modeling was done to estimate the potential impacts from a hypothetical accidental release. Finally, worst-case scenarios are evaluated. The result of this analysis is a projected failure rate for each failure mode [for example equipment failure, corrosion, operator error etc.]. The projected failure rate is determined by multiplying the historic failure rate per mile of carbon dioxide pipeline per year times the total length of carbon dioxide pipeline. The report concludes with a risk evaluation which is principally presented through a Project Risk Matrix. Mitigation measures are then described. The risk probability calculation concludes that the failure rate for the 4 mile carbon dioxide pipeline is estimated to be about 0.0007 failures per year.

Earlier testimony was presented citing the low incident rate for CO_2 pipelines which is supported by information in Table IV.B.12. This data shows that 18 incidents occurred over a

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[190] See generally, "Carbon Dioxide Pipelines: A Preliminary Review Of Design and Risks", J. Barrie et al.,

[191] Some authors express the view that pipeline transportation of carbon dioxide is safe. "Years of experience have led to a regulatory regime and operating procedures that make the operational subsystem [pipeline transportation] a safe, reliable and time-tested component of a CO2 storage system." Environmental Assessment of Geologic Storage of CO_2. Jason J. Heinrich et al., Laboratory for Energy and the Environment, Massachusetts Institute of Technology, Presented at the Second National Conference on Carbon Sequestration, Washington, DC, May 5-8, 2003.

[192] Ibid 135

[193] Ibid 137,

[194] Available at http://www.energy.ca.gov/sitingcases/hydrogen_energy/documents/applicant/revised_afc/Volume_II/Appendix%20E.pdf. The subcommittee expresses no view about whether this risk assessment is legally sufficient, complies with any particular requirement, is technically sufficient, or appropriate to the circumstances. It is given simply as an example of a recent carbon dioxide pipeline risk assessment.

3,769 mile network over more than 30 years of operations, less than one incident per year across the whole network. On a per mile basis, this is 0.0002 incidents per year. There were no injuries or fatalities due to any of these incidents. This kind of analysis is typical of risk assessment. Its advantage is that it provides a quantitative, or in this case a semi-quantitative assessment of the risks involved. This is very useful. The disadvantage is that it contains a number of assumptions and estimates, not all of which are readily apparent. The value of the risk assessment depends as much on the validity of the data as it does on the validity of the model.

IV.B.5.f.3: Geologic Sequestration

Geologic storage of carbon dioxide presents the risk of escape of carbon dioxide to the surface presenting a potentially hazardous situation to human health and the environment.[195] In addition, there are risks of: contamination of water supplies and potentially usable groundwater supplies; mobilization of contaminates in underground formations; and potentially increasing the expense of production of coal, gas and other mineral resources in the vicinity of sequestration operations. Finally, there is a risk of triggering a seismic event.

There is limited experience with projects that are only geologic storage of carbon dioxide. This limited experience requires consideration of analogous situations. Injection and storage of carbon dioxide underground has similarities to, and significant differences from, underground injection of brine wastes from oil and gas development, underground injection of wastes, injection of carbon dioxide for enhanced oil recovery, and the storage of natural gas. This experience can be used to assess the risks of geologic storage, and also to identify areas where the existing geologic information is inadequate.[196] In general it is believed that the risks of geologic storage of carbon dioxide change over time. The risks are greatest during and immediately after active injection. Thereafter, with the decline of reservoir pressure towards earlier in situ levels the risks decline.[197] Since long-term storage of carbon dioxide is measured in hundreds of years or longer, the potential long-term risks must be carefully considered. There is a significant and growing body of risk assessment literature directed at the geologic storage of carbon dioxide.[198,199] Of particular interest is the development of modeling techniques for carbon dioxide storage. These risk assessments will generally consider two kinds of scenarios: (1) the general risk of escape of carbon dioxide to the atmosphere, i.e., that the long-term storage of

[195] "The amount of CO2 that would need to be injected into geologic storage reservoirs to achieve a significant reduction of atmospheric emissions are very large. A 1000 MW coal-fired power plant emits approximately 30,000 tonnes of CO2 per day, 10 Mt per year (Hitchon, 1996). When injected underground over a typical lifetime of 30 years of such a plant, the CO2 plume may occupy a large area of order 100 km² or more, and fluid pressure increase in excess of one bar (corresponding to 10 m water head) may extend over an area of more than 2, 500 km² (Pruess, et al. 2003). *On CO2 Behavior in the Subsurface, Following Leakage from a Geologic Storage Reservoir, Pruess, Karsten, Lawrence Berkeley National Laboratory. 2006.*

[196] How analogous situations can be used to estimate risks associated with geologic storage of carbon dioxide is discussed in greater detail in table 5.5 of Underground Geologic Storage in Carbon Dioxide Capture and Storage, IPCC Special Report, 2005. Found at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports_carbon_dioxide.htm

[197] "It is an important technical consideration that "risk" associated with injected CO2 is not constant with time. The probability of an unexpected event increases as injection volumes and subsurface pressure ramp up and this requires close monitoring during the operations phase. After injection stops, as pressure equilibriates, and natural trapping mechanisms take effect, the injected CO2 becomes progressively more in mobile." A Technical Basis for Carbon Dioxide Storage; CO2 Capture Project, 2009. The CO2 Capture Project is an effort funded by a consortium of energy companies.

[198] A very useful companion to the risk assessment literature is "Vulnerability Evaluation Framework For Geologic Sequestration of Carbon Dioxide", July 10, 2008 United States Environmental Protection Agency, EPA 430-R-08-009. US EPA developed the Vulnerability Evaluation Framework to identify those conditions that could increase the potential for adverse impacts from geologic storage of carbon dioxide. It is a non-quantitative assessment.

[199] A comprehensive overview of international risk assessment issues is found in "Phase I Final Report from CSLF Risk Assessment Task Force", October 2009, Carbon Sequestration Leadership Forum.

carbon dioxide will not be achieved; and (2) more specific risks of injury to human health and the environment. There are also models for specific subparts of geologic storage such as models for leaks associated with well integrity.[200] As particular projects go forward there will be site-specific risk assessments. The ultimate risk assessment will be done by those who finance sequestration projects.

Two authors, quoted below, conclude that the risks of geologic storage of carbon dioxide are manageable. These authors rely upon the experience in similar fields such as natural gas storage and enhanced oil recovery for their views.[201]

> With appropriate site selection informed by available subsurface information, a monitoring program to detect problems, a regulatory system, and the appropriate use of remediation methods to stop or control CO_2 releases if they arise, the local health, safety and environmental risks of geologic storage would be comparable to risks of current activities such as natural gas storage, EOR, and deep underground disposal of acid gas. *Carbon Dioxide Capture and Storage, Summary for Policymakers And Technical Summary, Intergovernmental Panel on Climate Change, p. 11.*

> On a project –by- project basis, the risks of geologic storage of CO_2 are expected to be no greater than the risks associated with analogous industrial activities that are under way today. Oil and gas production operations, natural gas storage, and disposal of liquid and hazardous waste have provided experience with underground injection of fluids and gases on a massive scale. The injection volume of an individual storage project will be comparable to large-scale CO_2 EOR projects taking place in the U. S. today. Because the technology for characterizing potential CO_2 storage sites, drilling injection wells, safely operating injection facilities, and monitoring will be adapted and fine-tuned from these mature industrial practices taking place today, it is reasonable to infer that the level of risk will be similar. *Carbon Dioxide Capture and Storage, Assessment of Risks from Storage of Carbon Dioxide in Deep Underground Geological Formations, Sally M. Benson Earth Sciences Division, Lawrence Berkeley National Laboratory, version 1.0 April 2, 2006 p. 4.*

Risk assessment of the long term storage of carbon dioxide at a particular site is done or assisted by mathematical modeling or simulations. Typical of this approach is the risk assessment done for the Weyburn project in Saskatchewan, Canada. Weyburn is an enhanced oil recovery project using carbon dioxide.[202] This risk assessment used two different mathematical models to assess the probability that carbon dioxide will remain stored for the foreseeable future. The modeling estimates that "[t]here is a 95% probability that 98.7% to 99.5% of the initial CO_2 in place will remain stored in the geosphere for 5000 years."

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[200] See for example, "Supercritical CO2 Leakage Modeling For Well Integrity In Geological Storage Project", E. Houdu et al. Excerpt from proceedings of the COSMOL Conference 2008 Hanover.

[201] Again citation to, or quotation from particular sources does not indicate approval of the views cited to or quoted.

[202] See generally, Theme 4: Long-Term Risk Assessment Of the Storage Site, IEA GHG Weyburn CO2 Monitoring and Storage Project Summary Report 2000-2004, Volume III. From Proceedings of the Seventh International Conference Greenhouse Gas Control Technology, September 5-9, 2004, Vancouver, Canada. See page 212.

The most thorough site-specific risk assessment for geologic storage to date comes from the FutureGen project.[203] Table 6-11 Estimated Range of Failure Probabilities For Each Release Scenario By Candidate FutureGen Site estimates the probabilities of various failures including: upward rapid leakage through caprock; release through induced faults; and leaks due to undocumented deep wells. The time frame for consideration is 1000 to 5000 years.

For each scenario the probability of at least one failure in the time period is estimated, as is the probability of one failure annually. For the Jewett Texas site scenario, upward rapid leakage through caprock, the probability of at least one failure over the life of the project [1000 to 5000 years] is given as 0.003 to 0.14; while the estimated frequency of one failure occurring annually is 0.000001 to 0.00001.

These estimates, and the approach used to arrive at them, are the current state of the art. The value of these estimates is limited by a lack of track record [real-world data] for such projects, the assumptions necessary to make the estimates, and the nascent state of the models used. Nonetheless, for these two examples, and they may not represent the whole population, the risk assessment estimates very low risk.

Only a few conclusions can be drawn about the current state of risk assessment for geologic sequestration of carbon dioxide. First, such risk assessment for geologic storage is still in its infancy. There is very little real-world data on which to base a quantitative risk assessment. Analogous circumstances from other fields suggest, but do not prove, that carbon dioxide geologic storage risks are manageable. Second, the mathematical models used are undergoing rapid development and remain works in progress. Third, refinement of the risk assessments will be an iterative process. Fourth, the risk assessment literature, subject to the limitations expressed, generally supports continuing forward to establish a framework for such projects.

IV.B.6: Identify areas of research needed to better understand and quantify the processes of carbon dioxide sequestration §22-11A-6(h)(9)

A considerable amount of CO_2 sequestration research is currently underway by numerous groups. The most notable is the Department of Energy's National Energy Technology Laboratory. The seven Regional Carbon Sequestration Partnerships established by the DOE/NETL are global leaders in CO_2 sequestration research and application. Numerous universities, state agencies, and private companies participate in these partnerships as well as other DOE/NETL CCS research, including the University of West Virginia. In the international arena both the DOE/NETL and IEA actively support CO_2 sequestration research. It is the recommendation of this subcommittee that a West Virginian entity, either the West Virginia Department of Environmental Protection, the West Virginia Geological and Economic Survey or the West Virginia University, or a combination, be charged with tracking CO_2 sequestration research, application of this research and providing recommendations for further work if warranted. West Virginia will apply for primacy over Class VI permitting in the state. Establishing a group of people within the West Virginia Department of Environmental Protection, and/or the West Virginia Geological and Economic Survey and/or the West Virginia University who will track developing CCS technology, regulations and application will provide a strong base of knowledge to assist those charged with regulatory oversight. This arrangement can be informal within one organization or an informal agreement between organizations.

[203] Final Risk Assessment Report for the FutureGen project environmental Statement (revision to October 2007). See section 6.

The challenge will be to maintain budget continuity over time because labor hours will be spent on this effort and budgets will have to provide the necessary support.

IV.B.7: Conclusion for Geology & Technology Subcommittee

There is storage potential for sequestration of captured CO_2 in West Virginia. Present estimates of between 6,630 and 20,260 million metric tons can provide between 74 and 227 years of injection activity based on 90 percent capture of a statewide emission rate of 99.2 million metric tons. Storage potential is a resource and like any other natural resource it needs to be proven. This will be accomplished by the site characterization process prior to securing a permit to operate a CO_2 storage field.

The potential for sequestration of CO_2 extends over most of the state of West Virginia. Considering the potential for saline formation sequestration, the potential for sequestration of CO_2 probably exceeds the geographic range of oil & gas production in the state. The state overlies the sedimentary section of a portion of the Appalachian Basin, one of the major sedimentary basins in the continental United States. Thickness of this sedimentary section varies from about 8,000 feet to more than 20,000 feet. Potential for saline formation, depleted oil & gas reservoirs and unmineable coal seams are all present. Research on sequestration mechanisms in shales is continuing and these may present future opportunity. Due to geologic structural complexities along the Allegheny Structural Front, sequestration potential along the eastern boundary of West Virginia is very limited to non-existent.

Technology for a MVA program is available. How this technology will be applied, locations for sensors and/or sampling will depend on the overall geology of any particular storage field. The USEPA published final rules for Class VI injection wells in December 2010. These rules require direct measurement, via monitoring wells, and indirect measurement, via geophysical technology, of the storage reservoir, the seal and other relevant stratigraphy beneath the Area of Review, especially the groundwater horizons. Available technology is that developed and used in oil & gas exploration and production and its ability to differentiate between oil, natural gas and water is well tested. Level of resolution varies from pore scale with cores (subsurface rock samples) to formation scale with wireline logs to 2-D or 3-D seismic which cover wide geographic areas. The regional partnerships assembled by DOE/NETL are conducting research projects that further our understanding in the application of this technology for sequestration of CO_2.

Analogous areas of experience such as natural gas transportation and storage, underground injection of wastes and EOR suggest that carbon dioxide can be safely transported and stored. It does not imply that accidents will not happen. Natural gas storage and EOR operations are cyclic in nature; neither one injects CO_2 or natural gas with the intent of permanent storage. The intent of permanent retention of injected captured CO_2 is a new and significant aspect of sequestration. The sheer scale of finding "appropriately selected and managed geological reservoirs" with which to sequester thousands of millions of metric tons of captured CO_2 will be a daunting task. Risks associated with CO_2 pipeline and injection well operations are better understood than risks associated with sequestration of large volumes of captured CO_2. EOR operations inject, produce and re-cycle their CO_2. This process results in about half of the injected CO_2 becoming trapped, essentially sequestered in the reservoir. Geologic risks associated with sequestration, the long-term retention of CO_2, are more inferred from current practices. Depleted oil & gas reservoirs present a known reservoir with an effective seal. Saline reservoirs are not as well known and their extent and associated seal need to be discovered and assessed. As with the natural gas storage industry, there will successes and failures.

The process of developing a CO_2 storage reservoir, a regional geologic evaluation, selecting a suitable location for site characterization, securing rights to the pore space, securing permits, installation of injection wells, pipelines and equipment will take three to four years, perhaps as long as nine to eleven years. The Global CCS Institute estimated storge site characterization cost to be $25 million on average with a range of $10 to $150 million. Their study recommended assembling a list of six to eight prospects from which to select a site for characterization. There is some probability that the first site selected will not meet expectations and will have to be abandoned for another site. In their modeling they assumed a characterization cost of $60 million. The higher cost estimate from the Global CCS Institute's study suggests a 17 percent success rate.[204] Early movers here should have better success since they will be able to select optimal sites. Taking a global perspective, the International Energy Agency (IEA) looked at CCS storage costs with respect to meeting the goal of having 20 large scale CCS projects active by 2020. Their cost estimates ranged from €9 million to €81 million with an average of €30 million. At the current exchange rate of $1.44 per Euro, these costs are $13 million to $117 million with an average of $43 million.[205] The Global CCS Institute model assumed that it will take up to nine years before injection can begin. The IEA model assumes a similar time frame at a minimum. In Table 4E2, an estimate of between 3.5 and 6 years is suggested for regional geologic evaluation, site selection and characterization and permitting. If storage costs range from $5.00 to $10.00 per tonne then sequestering 100 million tonnes of CO_2 can cost between $500 and $1,000 million dollars. With site characterization a cost including permitting of $60 million, then it is easy to see that the majority of expenses incurred by sequestration occur after injection begins, driven by MVA activity, tracking the CO_2 plume and assuring non-endangerment at some point in time after injection is done.

Sequestration of captured CO_2 represents a significant cost, about $5 to $10 per tonne, but not as significant as the cost of capture in the electric power sector which can range from $32 to $107 per tonne depending on technology. Development of a storage field to the point where it can begin to receive captured CO_2 from a source and begin injection can take longer, some estimates up to 6 to 9 years, than construction of a power plant or the pipeline connection. This can present scheduling challenges in arranging for the coincident completion of installation of capture equipment at the plant, the pipeline connection and installation of injection equipment at the storage field. It is important to consider that the rate at which storage reservoirs can be permitted and developed will dictate the rate of deployment of CCS technology. Without storage, there is no need for capture.

Question 4: What legal and liability issues need to be decided before CCS can be pursued in West Virginia?

IV.C. LEGAL SUBCOMMITTEE REPORT

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[204] Glogbal CCS Institute, 2009, Strategic Analysis of the Global Status of Carbon Capture and Storage, Report 2: Economic Assessment of carbon Capture and Storage Technologies. Found at: http://www.globalccsinstitute.com/sites/default/files/Report%202-Economic%20Assessment%20of%20Carbon%20Capture%20and%20Storage%20Technologies_0.pdf

[205] IEA, 2011, Global Storage Resource Analysis for Policymakers, IEA CCS Costs Workshop, Paris, March 22-23, 2011. Found at: http://www.ieaghg.org/docs/General_Docs/IEAGHG_Presentations/Gap_Analysis_IEA_CCS_NW_Mar11_v2.pdf

IV.C.1. Background

As climate change is becoming a growing international concern, significant progress is being made by companies and states interested in assuring that there will be a place in the nation's energy future for coal fired electric power generation. Much of this effort is being focused on carbon capture and sequestration ("CCS") technology as holding the promise of being able to store carbon dioxide emissions from power plants and industrial facilities underground in deep storage sites. With several hundreds of years of storage potential at many locations across the nation, CCS is attracting much attention.

Initial CCS legislation was enacted by the West Virginia Legislature in 2009. The legislation created a carbon capture and sequestration regulatory program and created a working group to assess a variety of issues. CCS facilities are authorized by the legislation to the extent that the owner or operator holds an underground injection control permit authorized by state law for that purpose. W.Va. Code 22-11A-3(b). This final report to the Legislature addresses such issues as the ownership and acquisition of pore space and responsibility for long-term liability. Resolution of these issues will be critical in order to provide for the development of commercial scale CCS operations in West Virginia.

The effort to assess legal issues began by undertaking a careful review of activities around the country in identifying significant policy, regulatory and legal issues raised by CCS projects. In addition, several guest speakers provided information on program development in other jurisdictions. Among the guest speakers were Mary Throne, a member of the Wyoming legislature, Lynn Helms, Director of the , North Dakota Industrial Commission, Department of Mineral Resources), Sean McCoy and Lee Gresham of CCSReg/Carnegie Mellon University, Sara Smith, Chair of the Kentucky CCS Working Group, and Kurt Waltzer, Clean Air Task Force and contributor to the CCS recommendations of the Midwest Governors Association.

After identifying the universe of issues involved, initial efforts focused on property ownership and acquisition. Research was conducted on activities in other states and by such organizations as the Interstate Oil and Gas Compact Commission, CCSReg and the Midwest Governors Association. In addition, an evaluation was conducted of the consequence of doing nothing more than to allow current legal process to control the acquisition of land to be used for a CCS project. The goal of this effort was to explore all options in order to create a solution tailored to West Virginia legislature's desire to site commercial scale CCS projects.

The discussion of legal issues in this report will begin with a review of some of the more significant state level activities on CCS. The discussion will then turn to the six possible options which have been identified with a statement of the advantages and disadvantages of each option also provided. Next, the report will set forth the independent analysis of the Legal Subcommittee with respect to the law related to the circumstances under which the United States Constitution requires that a property owner be compensated for the use of property. The report will then offer a statement of which of the options involved is favored at this time. Specific text is then offered for the several matters that have thus far been considered. Finally a discussion draft of the West Virginia Carbon Dioxide Sequestration Act is offered as a starting point for the continued discussion of CCS in West Virginia.

IV.C.2. State-Based CCS Programs

Significant activity is occurring around the country in the development of state-based CCS programs. Among these initiatives are the following:

IV.C.2.a. IOGCC

In 2007 the Interstate Oil and Gas Compact Commission ("IOGCC") issued its model program for the storage of carbon dioxide in geologic formations. Even though the USEPA is applying the Safe Drinking Water Act regulatory program to CCS facilities, the IOGCC model program is premised on the belief that the regulation of CO_2 geological storage should be left to the states. With respect to property rights, the IOGCC model program provides that an applicant should acquire the property rights to use pore space in the geologic formation for storage. Interstate Oil and Gas Compact Commission, *CO_2 Storage: A Legal and Regulatory Guide for the States*, *at* http://iogcc.publishpath.com?Websites/iogcc/pdfs/Road-to-a-Greener-Energy-Future.pdf (Dec. 2007). While much of the IOGCC's model program addresses the need to acquire property rights through negotiation or eminent domain, the model program specifically states that the IOGCC is less concerned about what mechanism is used to acquire those rights and is more concerned that all necessary property rights be acquired by valid, subsisting and applicable state law. Following completion of the project, an operator would be obligated to monitor the project to assure its integrity. At the completion of that period, title to the facility would be transferred to the state and the operator and all generators of CO_2 injected would be released from all regulatory liability. The program establishes a trust fund that would assess a fee on each ton of CO_2 injected. The trust fund provides the financial resources for the state to take title to the project at the end of its operating life.

IV.C.2.b. Kansas

In 2007, Kansas established the authority to develop rules for CCS facilities. Kan Stat. Ann. §§55-1637 through 1640. Proposed administrative regulations issued in March 2009 address operational requirements for an environmental permitting program. Among those requirements is that the applicant must hold necessary property and mineral rights and own financial instruments that demonstrate financial responsibility. Kansas law does not define who owns pore space, nor does it define the level of financial responsibility required. To obtain a post-closure determination, the facility operators must demonstrate that the plume and storage pressure have stabilized. Upon written approval of post-closure status, the operator would plug the remaining monitor wells at which point the CO_2 storage facility permit would be revoked and any financial assurance instrument would be released. All future remediation or monitoring activities would be performed by the state.

IV.C.2.c. Louisiana

In 2009, the Louisiana Legislature passed new CCS legislation. Louisiana R.S. 30:1101 through 1111. *See* La. Rev. Stat. Ann. §§ 1101-111 (West 2009). This bill authorizes expropriation by the state or certain corporations engaged in CCS not only for a storage facility but also for pipelines for transportation. *Id*. Ten years, or any other time frame established by rule, after cessation of injection, a certificate of completion of injection operations would be issued at which time the storage operator, generators of the carbon dioxide, the owners of the carbon dioxide, and all other owners otherwise having an interest will be released from any and all regulatory duties or obligations and any other liability associated with or related to the storage facility. The statute authorizes a storage operator's fee.

IV.C.2.d. Montana

The Montana legislature passed CCS legislation (S.B. 498) in 2009 which established a CCS regulatory framework and addressed pore space ownership. *See* S.B. 498, 61st Leg. (Mont. 2009). Unless otherwise documented, the surface owner owns the pore space for geologic carbon sequestration. The bill also protects the existing rights of mineral owners and does not change common law regarding surface and mineral rights.

Operators will pay a fee on each ton of CO_2 injected into a storage reservoir based on anticipated actual expenses that will be incurred by agencies implementing the program. Prior to project completion, an operator is liable for the operation and management of the CO_2 injection well, the storage reservoir and the injected or stored CO_2. The completion and transfer of ownership and liability from the operator to the state is a process that takes 30 years: (a) 15 years after injection of CO_2 ends, a certificate of completion will be issued if the operator is in full compliance with all rules and (b) for a period of an additional 15 years after the certificate of completion is issued, the operator must continue adequate monitoring of the wells and reservoir and continue to accept all liability. Following the 15 year period of required monitoring and verification, if the operator has title to the storage reservoir and the stored CO_2, it may transfer the title to the state if the operator meets all requirements. Once the title is transferred to the state, the state is granted all rights and interests in and all responsibilities associated with the geologic storage reservoir and the stored CO_2. The transfer releases the operator from all regulatory requirements and liability associated with the reservoir and the stored CO_2. If the operator does not transfer title to the state, the operator accepts liability indefinitely for the reservoir and the stored CO_2.

IV.C.2.e. North Dakota

In 2009, Senate Bills 2139 (pore space and property issues) and 2095 (carbon dioxide storage operational issues) were enacted into law. *See*, S.B. 2139, 61st Leg. Reg. Ses. (N.D. 2009). This legislation creates a legal and regulatory framework for carbon capture and storage and addresses pore space and property issues relevant to carbon capture and storage, including placing title to pore space in all strata underlying the surface with the owner of the overlying surface estate. If a storage operator does not obtain the consent of all persons who own the storage reservoir's pore space, the state may require that the pore space owned by non-consenting owners be included in a storage facility and subject to geologic storage. *Id.* This is accomplished through the amalgamating provision, which is similar to unitization, requiring the consent of 60% of the property owners. *Id.*

Multiple funds are established to defray the expenses incurred by regulatory agencies throughout the carbon sequestration process. The actual fee amount is to be based upon the anticipated expenses that will be incurred in regulating storage facilities during their construction, operation, and pre-closure phases. The storage operator has title to the carbon dioxide injected into and stored in a storage reservoir and holds title until a certificate of project completion has been issued. While the storage operator holds title, the operator is liable for any damage the carbon dioxide may cause, including damage caused by carbon dioxide that escapes from the storage facility.

After project completion and application for closure, consideration will be given to issuing a certificate of project completion. Such certificate may not be issued until at least 10 years after carbon dioxide injections have ended. Once a certificate is issued, title to the storage facility and to the stored carbon dioxide transfers without payment of any compensation to the state and the storage operator and all persons who generated any injected carbon dioxide are released from all regulatory requirements and other liability associated with the storage facility.

IV.C.2.f. Oklahoma

In 2009, Oklahoma passed the "Geologic Storage of Carbon Dioxide Act" (S.B. 610). The act provides the legal framework to encourage the long-term geologic storage of carbon dioxide in Oklahoma. The Corporation Commission is granted the authority to grant certificates of public convenience and necessity and to authorize storage facilities which allows the storage operator to initiate the condemnation action necessary to site the facility. The act is almost silent with regard to addressing potential liability associated with CCS activities. However, it provides for the establishment of financial sureties or bonds.

IV.C.2.g. Wyoming

In 2009, Wyoming passed three bills to address ownership and liability issues related to geological storage of carbon dioxide. H.B. 57 clarifies that mining and drilling rights will be prioritized over geologic sequestration activities. *See* H.B. 57, 60th Leg., Gen. Sess. (Wyo. 2009). H.B. 58 provides that the injector holds the title and liability for sequestered carbon dioxide and all other materials injected during the sequestration process. *See* H.B. 58, 60th Leg., Gen. Sess. (Wyo. 2009). H.B. 80 establishes a procedure for unitizing geologic sequestration sites, whereby pore space rights from multiple parties would be aggregated for the purposes of a carbon storage project as long as 80 percent of the parties approve the project. *See* H.B. 80, 60th Leg., Gen. Sess. (Wyo. 2009). This suite of bills complements that which was passed in 2008. H.B. 89 specified ownership of pore space. H.B. 89, 59th, Leg., Gen. Sess. (Wyo. 2008). The 2008 legislation declared that the ownership of all pore space in all strata below the surface lands and waters of the state is declared to be vested in the owners of the surface above the strata. H.B. 90 established an operational regulatory program. H.B. 90, 59th Leg., Gen. Sess. (Wyo. 2008).

The legislation in the various states is setting the legal and regulatory framework for CCS projects in advance of the development of federal legislation. This work is allowing the current development of experimental CCS projects across the country. If commercial scale CCS projects are to be developed in time to play a meaningful role in framing national policy with respect to global climate change, these efforts to address legal issues must be accelerated. The WVCCS Legal Subcommittee is working toward resolution of the legal issues associated with the ownership and acquisition of pore space and responsibility for long-term liability.

IV.C.3. Pore Space Acquisition Options

As the result of its survey of proposals by other states and organizations, the subcommittee identified six alternatives related to the nature and extent of the obligation of an operator of a facility engaged in the geologic sequestration of carbon dioxide to acquire the property rights for that purpose. Those six alternatives are as follows:

Option 1. Existing Law

Legislation passed in 2009 provides an initial framework for CCS projects and in doing so relies upon the present state Water Pollution Control Act. While that 2009 legislation does not explicitly address eminent domain, eminent domain provisions do exist elsewhere in statutory law (see W.Va. Code, Chapter 54, Article 2). Even though the legislation requires that "necessary" legal rights to sequester CO_2 be demonstrated as part of the permitting process, the legislation does not define what rights are "necessary."

Advantages:

- Property rights may be acquired under existing property law.
- Existing law does not state what legal rights are necessary to sequester CO_2.
- This process would not require amendments to the current legislation.
- New legislation to begin acquiring the property rights would not be required.
- Current CCS law may allow electric utilities and others, such as the Public Energy Authority ("PEA") and the gas pipeline authority, to exercise eminent domain without further amendment.

Disadvantages:

- Requires a title search of existing property instruments to determine property ownership, which is time-consuming and expensive (there are 19,491 surface parcels and 1,026 mineral tracts in Mason County alone).
    - surface owners, oil and gas owners, coal owners, other mineral owners, and lien holders (deeds of trust, tax liens, judgment liens, other liens) must be identified.
    - A very conservative estimate of the title report costs would be $5,000 per tract.
- In the likely event all the necessary property cannot be acquired through negotiation, a condemnation action must commence.
- All compensation is paid by the condemnor along with the costs (commissioners, jury trial, etc.).
- Eminent domain is not authorized for any party other than utilities already having the power of eminent domain.
- Compensation to land owners would likely be variable.
- Uncertainty exists about the ownership of pore space and the obligation to acquire the right to use that pore space.

Option 2. Streamline Existing Law

Streamline existing law by including some or all of the following suggestions: (1) allow the use of tax records (updated to include transactions occurring in the past year) or other alternative methods to identify pore space ownership; (2) use Administrative Law Judge's ("ALJ") (or create a specific special master) as a first step in setting compensation; (3) expand the scope of existing eminent domain authority (gas pipelines, PEA); (4) expand entities with Certificate of Necessity from WVDEP/PSC (PSC would likely need to be involved for rates); (5) allow companies other than existing utilities the right to acquire the property rights and operate such facilities; (6) clarify who owns pore space under various scenarios; and (7) protect operators from common law claims (*e.g.* trespass) where CO_2 moves onto property not yet acquired.

Advantages:

- Simplifies the title search.
- Reduces costs and time.
- Might be able to provide some structure for controlling compensation.
- Does not purport to change existing ownership of pore space, but rather it simply creates a presumption of ownership in certain circumstances and allows that presumption to be rebutted, thereby protecting the rights of the owners.
- Allows an expanded group of applications.

Disadvantages:

- Requires changes to existing law.
- Still requires compensation for all property owners.
- Does not address the "windfall" value that may be created for the use of pore space for CO_2 sequestration.

Option 3. Public Use

The Midwest Governors Association has proposed that a state either unitize pore space or declare the subsurface below 2,500 feet not associated with hydrocarbon development to be accessible for public use. *See* Midwestern Governors Association, *Preliminary MGA Gologic Carbon Storage Utility Design Recommendations*, at http://www.midwesterngovernors.org/CCS/Meeting1/MGA_Preliminary_Geologic_Carbon_Storage_Utility_Design_Recommendations_September_2009.pdf (Sept. 2009). A fixed fee per acre will be provided for the use of the pore space. Eminent domain would be authorized. *Id*. at 4. This option has not yet been enacted into law by any state.

Advantages:

- Eliminates the uncertainty associated with determining the identity of the owner of the pore space.
- Simplifies compensation (set at nominal amount).
- Use of police powers may preclude (or minimize) compensation.

Disadvantages:

- Creates uncertainty to the extent that compensation is set below "fair market value."
- The issue of whether a legislative declaration of pore space below 2,500 feet constitutes a taking, which would trigger payment of just compensation, has not yet been tested.
- Due to variations in West Virginia's geology, the strata available for carbon dioxide sequestration may dip causing a depth line to pass in and out of a given stratum, potentially complicating the issue.
- Operator would still be required to bear the burden of determining ownership of pore space and of taking the right to use the pore space, even if CO_2 sequestration does not materially impair the pore space owner's use.

Option 4. Unitization

Unitization of pore space rights has been suggested by the Midwest Governors Association and has been enacted into the laws of North Dakota and Wyoming. *See* Midwestern Governors Association, *Preliminary MGA Gologic Carbon Storage Utility Design Recommendations*, at http://www.midwesterngovernors.org/CCS/Meeting1/MGA_Preliminary_Geologic_Carbon_Storage_Utility_Design_Recommendations_September_2009.pdf (Sept. 2009); S.B. 2139, 61st Leg. Reg. Sess. (N.D. 2009); H.B. 80, 60th Leg., Gen. Sess. (Wyo. 2009). The concept has not been applied to an actual CCS operation. Unitization would mandate that pore space rights can be used for CCS if a majority of rights are obtained by consent. Compensation for those additional rights is required and must be determined.

Advantages:

- The law could be amended to allow for its expanded use, as has been done in other states (such as Wyoming and North Dakota).
- The taking could occur without reliance upon new eminent domain authority.
- Efficient method.

Disadvantages:

- Current West Virginia law would need to be changed to expand unitization to include CO_2.
- Historically, unitization has assumed continued payment to the property owner.
- With CCS, there is no apparent, continual revenue stream or "product" beyond the operational stage of the project.

- The Wyoming program does not address how the affected property owners will be compensated.
- The price paid for the use of the pore space must be sufficient to entice a majority of the pore space owners to voluntarily relinquish the pore space for this to work effectively.
- It presumes an arms length/fair transaction between the parties, which may not always be the case.

Option 5. Permit Authorization

The Carnegie Mellon CCSReg Project has offered a comprehensive regulatory framework for geologic sequestration ("GS") based upon the balancing of the interests of private property owners with the public benefit of GS, and reducing the possibility of interference with other productive non-GS uses of the subsurface that are also in the public interest. *See* The Carnegie Mellon CCSReg Project, *Policy Brief: Regulating Carbon Dioxide Pipelines for the Purpose of Transporting Carbon Dioxide to Geologic Sequestration Sites, at* http://www.ccsreg.org/pdf/PipelineTransport_07013009.pdf (Sept. 2009). This framework should enable UIC regulators to permit GS projects and allocate use of subsurface pore space under an expanded version of the UIC program. Under this framework, regulators would consider the trade-offs between private interests and the public benefit of a proposed GS project, determining the safest, most efficient and equitable use of the pore space, including non-GS uses. This framework should increase the potential for either avoiding most subsurface property disputes outright, or resolving them at the outset in a stable and predictable environment that is fair and equitable to all affected parties. An approval by UIC regulators to allow the sequestration of CO_2 in that pore space could be challenged as a *per se* physical taking of property that requires compensation. A detailed discussion of the law of "takings" is set forth elsewhere in this report. U.S. Courts have consistently ruled that due to the overarching public benefit of underground disposal of fluid waste, technical trespass claims against waste injection operators properly licensed through the UIC permitting process are compensable only if a material impairment with use of the subsurface or the surface can be demonstrated. This same rationale has been applied to state-authorized enhanced oil and natural gas recovery operations and field unitization—that is, claims for subsurface trespass must yield to the public interest of efficiently producing natural resources. The CCSReg proposal and recommendations are set forth in a policy paper "Governing Access to and Use of Pore Space for Deep Geologic Sequestration" dated July 13, 2009.

Advantages:

- Expedited process and minimize cost.
- Property issues would be addressed during the permit process.
- Eliminating trespass would be very helpful.
- Eliminates the economic windfall that would be created by the passage of legislation mandating that pore space rights be obtained for CO_2 sequestration.

Disadvantages:

- Cutting off unasserted property rights, particularly for minors, may pose a problem.
- May unduly delay the issuance of the permit and without a valid permit it may not be possible to utilize the power of eminent domain needed to acquire the necessary pore space.

Option 6. Reverse Rule of Capture

Based upon the current application of the UIC program, the Ohio federal district court case involving the UIC program and the experience of the State of Florida with the underground injection of treated municipal wastewater, one option would be to establish a program that does not call for the taking of pore space rights. *See Baker v. Chevron USA, Inc. 2009 WL 3698418 (S.D. Ohio Nov. 4, 2009).* In Florida, property rights are generally not taken in connection with its extensive treated municipal waste disposal via the UIC program nor are they taken in connection with the underground injection of hazardous waste (however this often occurs on public land or offshore). David W. Keith et al., *Regulating the Underground Injection of CO2, at* http://www.ucalgary.ca/~keith/papers/73.Keith.ESTRegulatingCCS.e.pdf (Dec. 2005).

Advantages:

- Sequestration projects may be able to sequester carbon dioxide into pore space where they have no surface or mineral ownership interests.
- Reverse rule of capture involves acquiring rights to usage as opposed to ownership rights.
- Using the reverse rule of capture would eliminate the need to acquire the property rights to pore space.
- This would save considerable time and money.

Disadvantages:

- This approach might require characterization of this activity more as waste (and not commodity) management, which may create RCRA implications.
- Only a minority of states have adopted the reverse rule of capture rule and it is unclear whether states other than Ohio would follow this rule.
- It may subject the CCS operator to trespass or other common law claims.

Additional Legal Research on Permit Authorization Option

The subcommittee also considered additional legal research related to the option of allowing the permit in a proper case to authorize the use of pore space. This research addresses implications of the "Takings Clause" of the Fifth Amendment of the Constitution of the United States and of common law tort actions. Many of the cases discussed involve the injection of salt water or waste water into subsurface formations and its migration under properties of adjoining landowners. These cases are therefore analogous to the injection of carbon dioxide into subsurface pore space formations.

As discussed in the attached legal research, the law with respect to "takings" is principally addressed in four decisions of the United States Supreme Court.

Causby v. United States, 328 U.S. at 258 (1946), involved the question of whether the federal government's frequent and regular flights of aircraft over a property owner's land at low altitudes constituted a taking. 328 U.S. at 258. While the Supreme Court of the United States held that there was a taking under these circumstances, its holding was premised on the fact that the flights were "so low and so frequent as to be a direct and immediate interference with the enjoyment and use of the land." *Id*. at 266. Otherwise, the Court recognized, flights over private land are not a taking. *Id*. Specifically, the Court observed:

> [i]t is ancient doctrine that at common law ownership of land extended to the periphery of the universe – *Cujus est solum ejus est usque ad coelum*. But that doctrine has no place in the modern world. The air is a public highway, as Congress has declared. Were that not true, every transcontinental flight would subject the operator to countless trespass suits. Common sense revolts at the idea. To recognize such private claims to airspace would clog these highways, seriously interfere with their control and development in the public interest, and transfer into private ownership that to which only the public has a just claim.

Id. at 260. Thus, the Court recognized that "[t]he airplane is part of the modern environment of life, and the inconveniences which it causes are normally not compensable under the Fifth Amendment. The airspace, apart from the immediate reaches above the land, is part of the public domain." *Id*. at 266.

In *Penn Central Transportation Company v. City of New York*, the Supreme Court of the United States was faced with the question of whether the designation of a privately owned property as a "landmark" by a city landmark preservation committee, thereby preventing further construction on the property, amounted to a "taking" of the property without just compensation. 438 U.S. 104 (1978). The New York Court of Appeals concluded that there was no taking of the property since the landmark law did not transfer control of the property to the City, but rather, only restricted Penn Central's exploitation of it. *Id*. Further, the New York Court of Appeals found that Penn Central was not denied due process. The U.S. Supreme Court affirmed the decision of the New York Court of Appeals and identified several factors that have particular significance in resolving such claims. *Id*. These factors included the economic impact of the regulation on the property owner, the extent to which the regulation interfered with "distinct investment backed expectations," and the character of the government action, i.e., was the interference a physical invasion of the property by government or was the interference a public program adjustment to benefits and burdens of economic life in order to promote the common good. *Id*. In finding that landmark law did not interfere with Penn Central's present use of the Terminal, that Penn Central was still permitted to profit from its use of the Terminal and to obtain a reasonable return in its investment, and that Penn Central was not denied all use of the pre-existing air rights as they were transferable to other parcels in the vicinity, the Court concluded that the interference with Penn Central's property by the landmark law was not of such a magnitude that required the exercise of eminent domain and payment of compensation. *Id*. at 136.

In *Loretto v. Teleprompter Manhattan CATV Corp.*, the Supreme Court of the United States addressed the question of whether "a minor but permanent physical occupation of an owner's property authorized by government constitutes a 'taking' of property for which just compensation is due under the Fifth and Fourteenth Amendments of the Constitution." 458 U.S. 419, 421 (1982). At issue was a New York statute that required a landlord to permit cable television companies to install cable television facilities, or equipment, on the landlord's property for which the landlord was permitted to demand payment from the company of no more than an amount determined by a State Commission to be reasonable. The State Commission, acting in accordance with the statute, determined that a one-time payment of $1 was a reasonable fee. The Supreme Court of the United States held that the statute constituted a taking of property for which the property owner was entitled to just compensation under the Fifth and Fourteenth Amendments. Syl., *Loretto*, 458 U.S. 419. In arriving at this conclusion, the Supreme Court recognized that "[w]hen the 'character of the governmental action,' *Penn Central Transportation Co. v. New York City*, 438 U.S. 104, 124, 98 S.Ct. 2646, 2659, 57 L.Ed.2d 631, is a permanent physical occupation of real property, there is a taking to the extent of the occupation without regard to whether the action achieves an important public benefit or has only minimal economic impact on the owner." Syl., *Loretto*, 458 U.S. 419. There are, however, some distinguishable facts between those presented in *Loretto* and those involved with carbon sequestration. For instance, *Loretto* involved the installation, or "direct physical attachment," of cable facilities, which included plates, boxes, wires, bolts, and screws, to a building such that the facilities were "completely occupying" space immediately above and on the building's roof and along the building's exterior walls. These areas of the building are readily accessible and usable by its owners and may easily be put to other uses if so desired. Conversely, with respect to carbon sequestration in formations at least 2,500 feet beneath the surface, a property owner, unless already having an existing or reasonably foreseeable use of such a formation, cannot access this portion of his or her property without the expenditure of very significant financial resources and the use of sophisticated and expensive machinery and equipment. Thus, such formations are not even remotely readily accessible or easily put to other uses by the property owner. Further, in *Loretto*, the property to which the cable facilities were directly physically attached was of substantial economic value to its owners (i.e., residential rental property) and was in existing use by its owners (i.e., the property currently was being rented as residential living space by the owners).

The Loretto case was applied in *FPL Farming, Ltd. v. Texas Natural Resource Conservation Commission* in which a neighboring landowner's challenge to a state environmental commission's order allowing an industrial waste injection operator to increase a maximum injection rate of the industrial waste to a saltwater formation beneath the surface. No. 03-02-00477, 2003 WL 247183 (Tex.App.-Austin, Feb. 6, 2003). FPL contended that the permits amounted to an unconstitutional taking by allowing the waste plume to migrate under its property. *Id*. at 5. FPL asserted that it lost its right to possess the subsurface by being denied its ability to exclude the waste plume therefrom. *Id*. FPL also asserted that it lost its right to use the subsurface because the migrating waste plume would prevent FPL from mining the subsurface for brine or constructing its own injection well. *Id*. While the Court acknowledged that a permanent physical occupation occurs with government action that destroys a property owner's right to possess, use, and dispose of its property, the Court cast aside FPL's assertions as speculative. *Id*., citing *Loretto v. Teleprompter Manhattan CATV Corp.*, 458 U.S. 419, 435 (1982). The Court also found that FPL failed to meet the *Loretto* test for establishing a permanent physical invasion and a public taking in that FPL failed to demonstrate that it was denied an opportunity to apply for a brine mining permit or an injection well permit (i.e., that it was denied its right to possess, use, and enjoy the subsurface of its property) and that it was impaired in its right to sell its land as a result of the amended permits. *Id*. So, the Court concluded that there was no public taking of FPL's property as a result of the Commission's orders.

In *Lucas v. South Carolina Coastal Council*, the Supreme Court of the United States was asked to determine whether a land-use regulation's substantial impact on the economic value of private property constituted a taking under the Fifth and Fourteenth Amendments requiring the payment of just compensation. 505 U.S. 1003, 1007 (1992). Specifically, the State of South Carolina's Beachfront Management Act barred the petitioner, Lucas, from erecting any permanent habitable structures on his beachfront property, which he had purchased for that very purpose prior to the enactment of the Act. The Supreme Court of the United States found that the Act amounted to a taking of Lucas's property, entitling him to just compensation. In finding that the Act constituted a regulatory taking of Lucas's property, the Court held that regulations that deny a property owner of all "economically viable use of his land" amounts to a taking for which payment of just compensation is required. Syl., *Id*. at 1004. It is doubtful that the *Lucas* analysis would be problematic or used to attempt to invalidate a regulation permitting carbon sequestration in formations at least 2,500 feet beneath the surface since the property owner would still be entitled to all other uses of the property, whether economically viable or not.

Based on the foregoing case law, the subcommittee concluded that the following concepts/provisions should be considered for incorporation into underground carbon sequestration legislation:

- The legislation should elaborate, in detail, on the policy reasons for using subsurface formations for CO_2 sequestration, including public health, climate change, importance of coal industry to the state, recognition of justified limitations on subsurface property rights, and the public interest in the development of subsurface formations for CO_2 sequestration. The legislation should emphasize that subsurface CO_2 sequestration is a necessary and vital part of the modern environment of life in light of the challenges the world faces with climate change and increasing energy demands (echoing language used in *Causby*);
- The legislation should declare that the foregoing public policy concerns warrant the state's use of certain reservoirs throughout the state for the purpose of CO_2 sequestration;
- The legislation should declare that pore space, non-hydrocarbon bearing reservoirs within the boundaries of the state and (a) 2,500 feet beneath the surface or (b) between 2,500 feet and 12,000 feet beneath the surface ("reservoirs") that are not under an existing or reasonably foreseeable use by the respective property owner are part of the public domain (analogous to airspace "apart from the immediate reaches above the land, is part of the public domain" *Causby*);
- The legislation should authorize the West Virginia Department of Environmental Protection (or other state agency) to regulate the access to and use of the reservoirs for CO_2 sequestration;

- The legislation should authorize the WVDEP to define, by regulation, a permitting process by which parties may apply for a permit that authorizes the parties to access and use, exclusively for a defined length of time, the specific areas of the reservoirs defined and approved in the permit applications; the legislation and/or the regulations should require the party seeking the permit to obtain rights to use the surface from the surface owner for the injection well site;
- The legislation and/or the regulations should specify that, once an order granting a permit is issued and the party has secured the required surface rights to construct and operate an injection well, that party may access and use the permitted areas of the reservoirs for CO_2 sequestration in compliance with all provisions of the permit;
- The legislation and/or regulations should allow a property owner to pursue an inverse condemnation proceeding to recover damages if the property owner can establish that it has suffered actual physical damages to its property caused by the migration of CO_2 into the portion of the reservoir beneath the owner's property or that the migration of the CO_2 has actually interfered with the owner's existing or reasonably foreseeable use of its property. Otherwise, the injecting party will not be liable for common law tort claims brought by the property owner, including trespass and nuisance.

IV.C.4. Initial Assessment of Pore Space Acquisition Methodology

The Legislature has requested the Working Group to make recommendations to encourage the development of CCS and to examine factors integral to the construction, maintenance, and operation of CCS facilities, among other things. In response to this request, the Working Group turned its initial attention to the manner in which pore space rights are to be acquired.

The resulting analysis has focused principally on two overarching factors: (1) the practicality and cost of any approach that required that all owners of pore space be identified and paid for the right to use pore space without regard to the landowners potential for use of the pore space, and (2) the constitutional requirements applicable to the circumstances under which the use of land required compensation as a taking.

With respect to the first of these factors, the Working Group recognizes that in West Virginia and much of the East, the shear number of property owners that could be within the footprint of a CCS project could be extremely large. In Mason County, West Virginia alone, there are nearly 20,000 surface owners and 1,000 mineral owners. On the conservative assumption that a typical title examination could cost $5,000 per tract, the cost to do title searches for a project with a footprint as large as Mason County would be approximately $100 million. Added costs related compensation to landowners and transactional costs related to acquiring the property rights cause the Working Group to conclude that an alternative course of action should be pursued.

Turning then to the constitutional requirements related to compensation for the use of land, the Working Group recognizes that not all use of private land result in a compensable taking. The United States Supreme Court and other courts have recognized a number of circumstances in which compensation was not required to be paid for the use of land. These cases have included in certain circumstances airplane over-flights of land and injection of material into underground foundations.

The Working Group carefully assessed the proposal of the Midwest Governors Association to establish as having a public use certain pore space located below 2500 feet.

In addition the Working Group carefully evaluated the recommendation of the Carnegie Mellon CCSReg Project which offered a comprehensive regulatory framework for GS based upon the balancing of the interests of private property owners with the public benefit of GS, and reducing possibility of interference with other productive non-GS uses of the subsurface that are also in the public interest. This framework was based on the premise that UIC regulators shuld be enabled to permit CCS projects and allocate use of subsurface pore space under an expanded version of the UIC program. Under this framework, regulators would consider the trade-offs between private interests and the public benefit of a proposed CCS project, determining the safest, most efficient and equitable use of the pore space, including non-CCS uses. This framework should increase the potential for either avoiding most subsurface property disputes outright, or resolving them at the outset in a stable and predictable environment that is fair and equitable to all affected parties.

By reviewing the facts and circumstances surrounding theses cases, the Working Group has developed a statutory mechanism set forth in the following section that is believed to pass constitutional muster. The dedication of certain pore space below 2,500 feet to public use is the approach favored by the majority of the Working Group at this time.

IV.C.5. Legislative Elements

The following are elements of a legislative proposal that the subcommittee has concluded to be appropriate to address several components of the West Virginia Carbon Dioxide Sequestration Act (W. Va. Code 22-11A-1 through 9). Following the statement of each element, specific legislative language is set forth that would implement that element.

1. Pore Space Acquisition

Before injection begins, the applicant would need to demonstrate that it either has or is expected to have "necessary" property rights related to a CCS facility.

A “necessary” right would include appropriate rights needed for surface usage (i.e., pipelines, surface facilities, well locations etc.), appropriate rights needed for the construction of wells and appropriate rights to use certain geologic formations for the sequestration of carbon dioxide.

A “necessary” right shall not include the right to use a portion of a geologic formation for the purpose of sequestering CO_2 in the event that such geologic formation is located below 2500 feet and does not have a reasonably foreseeable use for a purpose other than the sequestration of carbon dioxide.

Amendment of existing section: W. Va. Code 22-11A-1

§ 22-11A-~~1~~2. Legislative findings.

(a) The Legislature finds that:

(1) Carbon dioxide is a colorless, odorless gas that can be produced by burning carbon and organic compounds;

(2) Carbon dioxide is emitted into the atmosphere from a number of sources including fossil-fueled power plants, automobiles, certain industrial processes and other naturally occurring sources;

(3) By far, fossil-fueled power plants are the largest source of carbon dioxide emissions. These power plants emit approximately one-third of carbon dioxide emissions worldwide;

(4) On average, the United States generates approximately fifty-one percent of its electricity from coal-burning plants, which are a prominent source of carbon dioxide emissions;

(5) West Virginia's reliance on electricity produced from coal is even more pronounced, as West Virginia generates approximately ninety-eight percent of its electricity from coal burning power plants;

(6) There is increasing pressure, both nationally and worldwide, to produce electrical power with an ever-decreasing amount of carbon dioxide emissions;

(7) West Virginia is a state rich in natural resources, and its economy depends largely upon the demand for energy produced from materials found within the state, not the least of which is coal;

(8) As demand for energy produced from alternative and renewable resources rises, new technologies are needed to burn coal more cleanly and efficiently if West Virginia is to remain competitive as an energy producing state;

(9) Carbon dioxide capture and sequestration is the capture and secure storage of carbon dioxide that would otherwise be emitted to, or remain in, the atmosphere. This technology is currently being used and tested to reduce the carbon footprint of electricity generated by the combustion of coal;

(10) The science of carbon dioxide capture and sequestration is advancing rapidly, but the environmental effects of large, long-term carbon dioxide sequestration operations are still being studied and evaluated;

(11) Although the state is committed to expanding its portfolio of alternative and renewable energy resources, electricity generated from these resources is insufficient in the near term to meet the rising demand for energy;

(12) It is in the public interest to advance the implementation of carbon dioxide capture and sequestration technologies into the state's energy portfolio;

(13) Inasmuch as the subsurface sequestration of carbon dioxide is necessary to confront the challenges the world faces with climate change and increasing energy demands, it is appropriate for the state to ensure that geologic formations throughout the state can be used for the purpose of carbon dioxide sequestration in accordance with this article;

(14) It is in the public interest to declare as a public use the use of portions of certain deeper geologic formations for the purpose of carbon dioxide sequestration in accordance with a permit issued pursuant to this article, so long as those portions of geologic formations do not have a current or reasonably foreseeable use for a qualifying purpose;

(15) The state should provide for a coordinated statewide program authorizing access to and use of specific portions of the geologic formations, regulating the injection, storage and withdrawal of carbon dioxide, and fulfilling the state's primary responsibility for assuring compliance with the federal Safe Drinking Water Act, including any amendments thereto;

(136) The transportation by pipeline and sequestration of carbon dioxide by a public utility engaged in the generation of electricity may be integral to the construction, maintenance and operation of electric light, heat and power plants operating in the state; and

(147) Therefore, in order to expand more rapidly the generation of electricity with little or no carbon dioxide emissions, it is critical to encourage the development of carbon dioxide capture and sequestration technologies; to examine factors that may be integral to the construction, maintenance and operation of carbon dioxide sequestration facilities; and to study the economic and environmental feasibility of large, long-term carbon dioxide sequestration operations.

(b) It is therefore the purpose of this article to:

(1) Establish a legal and regulatory framework for the permitting of carbon dioxide sequestration operations;.

(2) Designate a state agency responsible for establishing standards and rules for the permitting of carbon dioxide sequestration operations including, but not limited to, rules pertaining to:

(A) Environmental surveillance of carbon dioxide sequestration operations;

(B) The monitoring of geologic migration of carbon dioxide and the detection of carbon dioxide excursions;

(C) Construction standards for carbon dioxide sequestration operations;

~~(D) Bonding or other financial assurances; and~~

~~(E) The closure of carbon dioxide sequestration operations, including post-closure monitoring, verification and maintenance; and to~~

~~(3) With the aid of a carbon dioxide sequestration working group, develop a long-term strategy for the regulation of carbon dioxide sequestration.~~

The subcommittee notes that subsections 2, 3, 4, 5, and 6 of the above findings contain factual statements that should be reviewed for current accuracy.

Proposed new definitions:

§ 22-11A-~~2~~3. Definitions.

Unless the context in which used clearly requires a different meaning, as used in this article:

(a) “Authority” means the Carbon Dioxide Management Authority established pursuant to section thirteen of this article. ~~Department" means the Department of Environmental Protection~~;

(b) "Carbon dioxide sequestration" means the injection of carbon dioxide and associated constituents into ~~subsurface~~ reservoirs intended to prevent its release into the atmosphere;

(c) "Carbon dioxide sequestration ~~facilities" means the surface equipment used for transport, storage and injection of carbon dioxide, excluding pipelines used to transport carbon dioxide from one or more capture facilities to the sequestration injection site or sites.~~ facility” means the reservoir, the underground equipment and pipelines internal to the carbon dioxide sequestration operation, including injection and withdrawal wells and appurtenant equipment, monitoring wells and appurtenant equipment, and surface buildings and equipment utilized in the sequestration operation, but excluding pipelines used to transport the carbon dioxide from one or more capture facilities to the sequestration injection site or sites. The carbon dioxide sequestration facility also includes any necessary and reasonable areal buffer and subsurface monitoring zones and monitoring wells designated by the secretary for the purpose of ensuring the safe and efficient operation of the sequestration facility for the sequestration of carbon dioxide and to protect against pollution, invasion, and escape or migration of carbon dioxide. A carbon dioxide sequestration facility shall not include carbon capture equipment located at the generator of the carbon dioxide.

~~(d) "Carbon dioxide sequestration site" means the underground carbon dioxide formations where the carbon dioxide is stored or is intended to be stored;~~

(d) “Carbon dioxide transmission pipeline” means a pipeline, compressors, meters and associated equipment and appurtenances used for the purpose of transporting carbon dioxide in this state for underground storage in this state or another state. A carbon dioxide transmission pipeline shall not include carbon capture equipment located at the generator of the carbon dioxide or pipelines that are part of a carbon dioxide sequestration facility. The commission shall establish by rule the beginning point and ending point of a carbon dioxide transmission pipeline.

(e) "Certificate of completion" means a certification issued by the secretary that the project operator has completed injection operations, well closure, and any required monitoring and remediation at a carbon dioxide sequestration facility, after a determination is made that there is a reasonable basis to believe that carbon dioxide is and will continue to be safely stored at the carbon dioxide sequestration facility and will not present an unreasonable risk to health, safety, or the environment, (including drinking water supplies).

(f) "Civil liability claim" means any claim for civil relief with respect to a carbon dioxide sequestration facility that arises from migration of carbon dioxide from such facility or is otherwise related to the injection of carbon dioxide at such facility, excluding:

(1) any claim arising from breach of an express contract, or

(2) in the case of a project operator, any claim arising from (i) willful violation of applicable rules of the regulatory authority, or (ii) any false statement or misrepresentation in an application for a certificate of completion;

(g) "Closed sequestration facility" means a carbon dioxide sequestration facility for which a certificate of completion has been issued;

(h) "Department" means the department of environmental protection;

~~(e) "Excursion" means the migrating of carbon dioxide at or beyond the boundary of a carbon dioxide sequestration site; and~~

(i) "Geologic formation" means a succession of sedimentary beds that were deposited continuously and under the same general conditions, composed of the same kind of rock or a distinctive combination of rock types, and includes the pore space within the succession of sedimentary beds.

(j) "Permit issued pursuant to this article" means a permit issued by the secretary pursuant to this article for the sequestration of carbon dioxide in reservoirs.

(k) "Project operator" means the entity responsible for the operation of a carbon dioxide sequestration facility.

(l) "Public liability" means tort liability respecting a closed sequestration facility, including, without limitations, liability for

(1) personal injury,

(2) property damage,

(3) trespass, and

(4) nuisance.

Such term does not include liability for punitive damages or non-economic losses.

(m) “Qualifying purpose” means the lawful use of reservoirs for any significant purpose, including but not limited to, the storage of natural gas, or the extraction of oil, natural gas, coal, coalbed methane or other minerals in such quantity and quality as to justify commercial production of that oil, natural gas, coal, coalbed methane or other mineral, but does not include the use of such reservoirs for the purpose of storing or sequestering carbon dioxide.

(n) “Regulatory authority” for a carbon dioxide sequestration facility means the Department of Environmental Protection.

(o) “Remediation” means action to remedy leakage or migration of carbon dioxide, including any damages to underground drinking water supplies, or to mitigate or correct other danger to health, safety, or the environment that occurs by reason of prior injection of carbon dioxide at a closed carbon dioxide sequestration facility.

(p) “Reservoir” means that portion of a geologic formation with natural or artificial pore space and suitable for or capable of being made suitable for the injection and sequestration of carbon dioxide.

(~~f~~q) "Secretary" means the secretary of the Department of Environmental Protection.

(r) “Stewardship responsibility” means responsibility for monitoring and remediation of closed carbon dioxide sequestration facilities as provided in section fifteen of this article.

The CCS permit will be the mechanism for determining whether there is an existing use, for resolving disputes about competing uses, and for authorizing the use of the geologic formation for the sequestration of carbon dioxide.

Proposed statutory language

§22-11A-7. Determination of property rights; right to inject into reservoirs within permit boundaries.

(a) The applicant must demonstrate that the applicant has, or will have prior to the commencement of the operation, all necessary legal rights, including without limitation the right to surface or reservoir use, necessary to sequester carbon dioxide and associated constituents and to transport it to the proposed carbon dioxide sequestration facility. A necessary legal right shall not include the right to use for that purpose a reservoir located at a depth of two thousand five hundred feet or more below the surface of the land which, on the effective date of a permit issued pursuant to this article, does not have a current or reasonably foreseeable use for a qualifying purpose. Such right to use such reservoirs located at a depth of two thousand five hundred feet or more below the surface is hereby declared to be a public use and no compensation shall be required to be paid solely for such use.

(b) During the permit application public comment period, potentially affected property owners shall have the opportunity to demonstrate that such facility will impair a current or reasonably foreseeable use of the reservoir for a qualifying purpose. If impairment is demonstrated, the secretary shall issue a permit for such facility upon the condition that the operator:

(1) reach a contractual agreement with such owner resolving the claim;

(2) modify the carbon dioxide sequestration facility so that it avoids the impairment; or

(3) amalgamate property rights as authorized or preserved in accordance with and to the extent allowed by section eight of this article.

(c) In the absence of a showing that the reservoir proposed for use has a current or reasonably foreseeable use for a qualifying purpose that is likely to be materially impaired by the proposed facility, the public interest associated with sequestering carbon dioxide in reservoirs to help mitigate effects of climate change shall prevail over any claimed right of the owners of any rights in such reservoirs to exclude operators who are properly licensed pursuant to this article. Therefore, an operator conducting activity pursuant to a permit issued pursuant to this article for the sequestration of carbon dioxide in suchreservoirs shall have the right to inject into and occupy the reservoirs within the boundaries designated by such permit in all areas in which all portions of such reservoirs are located at a depth of two thousand five hundred feet or more below the surface of the land and which, on the effective date of such permit, do not have a current or reasonably foreseeable use for a qualifying purpose at the time of permit issuance that is likely to be materially impaired by the proposed project.

(d) In the event that a property owner becomes aware of information that was not known or reasonably ascertainable at the time of the issuance of a permit under this article, the property owner may petition the secretary for a determination that the subject carbon dioxide sequestration facility will impair a then current or reasonably foreseeable use of the reservoir for a qualifying purpose. Should the secretary determine on the basis of such petition and any timely response that the subject facility will impair such use, such property owner and the owner or operator of the subject facility may submit for approval by the secretary a mutually agreeable plan that would allow for the property owner to undertake such use in a manner that would not unreasonably interfere with the subject carbon dioxide sequestration facility. The secretary shall approve the plan and modify the permit as may be appropriate to implement the plan.

2. Restriction on use of mineral bearing and other formations and permitting by the WVDEP

The operator should not be allowed to store CO_2 in reservoirs bearing oil, natural gas, coal, coalbed methane, or other minerals in such quantity and quality as to justify commercial production unless that formation is owned by the operator, or the operator has permission of the owner to authorize such a use. The operator shall be required to obtain a permit pursuant to the West Virginia Carbon Dioxide Sequestration Act from the West Virginia Department of Environmental Protection ("WVDEP") prior to the construction, operation or modification of a carbon dioxide sequestration facility. In order to obtain the permit, WVDEP may require the applicant to obtain a certificate of public convenience and necessity from the Public Service Commission ("PSC") in addition to the other requirements. The permit issued under article 11A, chapter 22 of the West Virginia Code shall be transparent with the federal Safe Drinking Water Act, relating to the state's participation in the Underground Injection Control ("UIC") program in that a separate application will not be necessary. The permit will also supplant the need for a "well work" permit. The operator will be required to demonstrate appropriate financial responsibility throughout the injection process and through closure. The permitting requirements should mandate that construction on the facility begin within a specified period of time following permit issuance.

§22-11A-~~3~~4. Requirement to have a permit; authorization for existing carbon dioxide sequestration facility; permit requirements; experimental wells; interference with other sequestration facility; public notice requirements; jurisdiction; application to enhanced recovery; application of article six; judicial review.

~~**Prohibition of carbon dioxide sequestration without a permit; injection of carbon dioxide for the purpose of enhancing the recovery of oil or other minerals not subject to the provisions of this article.**~~

~~(a) The provisions of article eleven of this chapter apply to all permits issued pursuant to this article except, where the express provisions of this article conflict with the provisions of article eleven of this chapter, the express provisions of this article control.~~

~~(b) Except as set forth in subsection (c) of this section, no person shall engage in carbon dioxide sequestration in this state unless authorized by a permit issued by the department in accordance with section eight, article eleven of this chapter.~~

(a) The owner or operator of a carbon dioxide sequestration facility shall obtain a permit pursuant to this article from the secretary prior to the construction, operation or modification of such facility.

(~~c~~b) The injection of carbon dioxide for purposes of enhancing the recovery of oil or other minerals pursuant to a project approved by the department or for the production of carbon dioxide in connection with the production of natural gas shall not be subject to the provisions of this article.

(~~d~~c) If an oil ~~natural gas or coalbed methane~~ or other minerals recovery operator converts its operations to carbon dioxide sequestration upon the cessation of oil or other mineral recovery operations, then the carbon dioxide sequestration facility ~~the carbon dioxide sequestration site~~ shall be regulated pursuant to this article ~~and article eleven of this chapter~~. ~~If an operator does not convert its operations to carbon dioxide sequestration upon the cessation of oil or other mineral recovery operations, the wells shall be plugged and abandoned in accordance with article six of this chapter.~~

~~(e) Any entity owning or operating a carbon dioxide sequestration facility which has commenced construction on or before the effective date of this article is hereby authorized to continue operating until such time as the secretary has established operational and procedural requirements applicable to such existing facilities and the entity owning or operating such facility has had a reasonable opportunity to comply with those requirements.~~

(~~b~~d) Any entity owning or operating a carbon dioxide sequestration facility in existence on the effective date of this article shall be deemed to have a permit pursuant to this article, upon which the secretary may prospectively impose reasonable conditions after providing the owner or operator of such facility with notice and opportunity for a hearing. Any such entity failing to comply with such prospective reasonable conditions shall be subject to all of the remedies available to the secretary pursuant to this article.

(~~c~~e) A carbon dioxide sequestration facility is hereby authorized, provided that the secretary shall first issue a permit authorizing such facility and designating the horizontal and vertical boundaries of both the surface and subsurface areas to be used for such facility. In order to issue a permit to authorize a carbon dioxide sequestration facility, the secretary must find:

(1) that, if necessary, an applicant has obtained or applied for a certificate of public convenience and necessity from the public service commission pursuant to article two, chapter twenty four of this code;

(2) that (a) the portion of the geologic formation being proposed for such a facility has characteristics suitable for, or which can be made suitable for, use as a reservoir through fracturing or other demonstrated techniques, (b) the boundaries of such facility can be established with reasonable certainty, and (c) such facility is otherwise

suitable and feasible for the injection, sequestration and, if proposed, withdrawal of carbon dioxide;

(3) that the use of such facility for the sequestration of carbon dioxide will not contaminate other geologic formations containing fresh water;

(4) that such facility will not be used to inject carbon dioxide into that portion of a geologic formation being used to store natural gas within the certificated boundaries (including the protective area) of an existing natural gas storage field certificated by the federal energy regulatory commission or the public service commission;

(5) that such facility will not be used to inject carbon dioxide into a portion of a geologic formation bearing oil, natural gas, coal, coalbed methane, or other mineral in such quantity and quality as to justify commercial production of that oil, gas, coal, coalbed methane, or other mineral, unless the proposed facility operator demonstrates that, in addition to any other property rights required by this article, it is the owner in fee of such portion of a geologic formation or that it has obtained the voluntary rights from the property rights holders of such portion of a geologic formation to inject carbon dioxide into such portion of a geologic formation.

(6) that such facility will be operated in such a manner as to protect human health and the environment; and

(7) that the quality of the carbon dioxide to be managed will not compromise the safety or structural integrity of such facility.

(~~d~~f) The secretary is authorized to establish by rule an abbreviated process for the purpose of authorizing temporary research or experimental wells for the sequestration of carbon dioxide for a finite period of time.

(~~e~~g) The secretary shall adopt legislative rules to govern the relationship between competing carbon dioxide sequestration facilities. In the event one carbon dioxide sequestration facility is interfering or may interfere with another carbon dioxide sequestration facility, the secretary shall, after notice and opportunity for hearing, resolve the dispute by requiring remediation actions, by taking enforcement actions, or by imposing such permit modifications as may be necessary to resolve the dispute and avoid future interference.

(~~f~~h) Public notice required by this subsection shall be a Class I legal advertisement in a newspaper in general circulation in a county or counties where the carbon dioxide sequestration facility will be located. The secretary shall publish public notice upon issuance of a draft permit stating where the public can review the draft permit and the nature of the public's opportunity to comment on the draft permit. The secretary shall also issue a public notice announcing any public hearing that may be held on the draft permit. Prior to approval of any permit for such facility, the secretary may upon receipt of a written request of a person having expressed concern or objections to the proposed permit, cause a public hearing to be held in the locality where such facility is proposed to be located for the purpose of receiving comment regarding the expected or perceived impacts of such facility on the local area. The secretary shall allow at least thirty days for public comment on the draft permit. Upon request of the permit applicant, the public comment period may be extended for an additional thirty days. Further extension of the comment period may be granted by the secretary for good cause shown, but in no event may the further extension of the public comment period exceed ninety days. Public notice of a public hearing shall be given at least thirty days before the hearing. Public notice of the hearing may be given at the same time as public notice of the draft permit and the two notices may be combined. The secretary shall establish by rule the procedures applicable to such notices, including but not limited to the content of public notices, the content of the public notice of hearing, the management of public comments filed, and any and all other requirements of chapter twenty-nine-a of this code.

(~~g~~i) Notwithstanding any other provision of this code to the contrary, no agency of state government or any political subdivision may regulate any carbon dioxide sequestration facility or carbon dioxide transmission pipeline except as expressly authorized pursuant to this article.

(~~h~~j) Except as provided in article two, chapter twenty four of this code and article one, chapter twenty-four-b, the secretary shall have sole and exclusive jurisdiction and authority over all entities and property necessary to issue or to deny permits or to otherwise regulate the siting and environmental aspects of carbon dioxide sequestration facilities or carbon dioxide transmission pipelines in accordance with this article, to monitor and enforce compliance with permit conditions and the legal requirements established in accordance with this article, and to regulate any subsequent withdrawal of sequestered carbon dioxide. In exercising such jurisdiction and authority, the secretary may conduct hearings, issue and enforce orders, and adopt, modify, repeal and enforce procedural, interpretive and legislative rules in accordance with chapter twenty-nine-a of this code concerning geologic sequestration and withdrawal of carbon dioxide from carbon dioxide sequestration facilities.

(~~i~~k) The requirements of articles six and nine of this chapter shall not apply to wells subject to the requirements of this article. In addition, no well subject to the requirements of this article shall be subject to the jurisdiction of the oil and gas conservation commission, the shallow gas well review board, or the coal bed methane review board regardless of depth, well spacing, production of hydrocarbons, or otherwise. Any issues regarding depth, well spacing, setback from boundary lines, safety procedures, and production of hydrocarbons shall be subject to the sole jurisdiction of the secretary pursuant to this article. The secretary may combine the data collected for wells associated with a carbon dioxide sequestration facility into other data bases.

(~~k~~l) Any person adversely affected by an order made and entered by the secretary in accordance with the provisions of this article, or aggrieved by the failure or refusal of the secretary to act within a reasonable time on an application for a permit or aggrieved by the terms and conditions of a permit granted under the provisions of this article, may appeal to the Environmental Quality Board, pursuant to the provisions of article one, chapter twenty-two-b of this code.

(m) The secretary shall have the authority to regulate carbon dioxide transmission pipelines to the extent allowed under any article of this code other than this article.

3. Other WVDEP authority

The secretary has additional powers and duties with respect to carbon dioxide sequestration, which are provided below.

§22-11A-~~4~~5. General powers and duties of the secretary with respect to carbon dioxide sequestration.

(a) The secretary, after receiving public comment and after consultation with the state geologist and the working group established in section ~~six~~ seventeen of this article, shall promulgate legislative rules in accordance with the provisions of article three, chapter twenty-nine-a of this code to implement the provisions of this article, including, without limitation:

(1) The requirements for issuance of permits for carbon dioxide sequestration;

(2) The requirements for carbon dioxide sequestration permit applications;

(3) The issuance of notice following the approval of a permit application, which ~~shall identify the location at which the public may examine the permit, describe the nature of the public's opportunity to comment, and list any public hearing that may be held in connection with the permit. The secretary shall allow no less than thirty days for public comment on the draft permit and may for good cause extend the comment period up to an additional thirty days. Notice of any public hearing shall be given no less than thirty days prior to its conduct~~ notice shall be in accordance with section four of this article; and

(4) The creation of subclasses of wells within the existing Underground Injection Control (UIC) program administered by the United

States Environmental Protection Agency pursuant to Part C of the Safe Drinking Water Act, 42 U.S.C. §300h, *et seq.*, to protect human health, safety and the environment and to allow for the separate permitting of wells for the sequestration of carbon dioxide;

(5) The appropriate bonding or other financial assurance procedures necessary to ensure that carbon dioxide sequestration ~~sites and~~ facilities will be constructed, operated and closed in accordance with the purposes and provisions of this article; and

(6) The proper duration of the post-closure care period for carbon dioxide sequestration ~~sites~~ facilities.

(b) The secretary shall propose amendments to the rules promulgated under this section and take such action as may be required in order to fulfill the state's primary responsibility for assuring compliance with the federal Safe Drinking Water Act, including any amendments thereto.

(c) The secretary upon presentation of credentials: (i) has a right of entry to, upon or through any premises in which a carbon dioxide sequestration facility or closed sequestration facility is located or in which any records required to be maintained under this article are located; and (ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method required under this article and take such samples which the owner or operator of such facility or pipeline is required to sample under this article. Nothing in this subsection eliminates any obligation to follow any process that may be required by law.

(d) The secretary has the authority to enter at all reasonable times upon any private or public property for the purpose of making surveys, examinations, investigations and studies needed in the gathering of facts concerning the carbon dioxide sequestration facility or closed sequestration facility and its use, subject to responsibility for any damage to the property entered. Upon entering, and before making any survey, examination, investigation and study, such person shall immediately present himself or herself to the person in charge of the operation, and if he or she is not available, to a managerial employee. All persons shall cooperate fully with the person entering such property for such purposes. Upon refusal of the person owning or controlling such property to permit such entrance or the making of such surveys, examinations, investigations and studies, the secretary may apply to the circuit court of the county in which such property is located, or to the judge thereof in vacation, for an order permitting such entrance or the making of such surveys, examinations, investigations and studies; and jurisdiction is hereby conferred upon such court to enter such order upon a showing that the relief asked is necessary for the proper enforcement of this article:

Provided, That nothing in this subsection eliminates any obligation to follow any process that may be required by law.

4. Primacy of mineral estate

The mineral owner should be able to make reasonable use of the subsurface for mineral exploration or production. The holder of a mineral interest should not be prevented from exercising its lawful rights in a manner that will not compromise the safety or integrity of the CO_2 sequestration project. If such rights cannot be exercised without compromising the sequestration project, such activities should be restricted or precluded to the extent necessary to protect the safety or integrity of the sequestration project, without compensation being required. However, if the mineral interest owner or holder believes the prohibition amounts to an uncompensated regulatory taking, it may file an inverse condemnation claim. While the use of eminent domain/pooling is not authorized at depths of less than 2500 feet from the surface to secure the right to place CO2 into a formation, eminent domain/pooling is authorized for such other purposes as construction of wells.

Proposed statutory amendment:

§22-11A-~~8~~10. Oil, natural gas and coalbed methane activities at carbon dioxide sequestration ~~sites~~ facility; extraction of sequestered carbon dioxide.

(a) Nothing in this article shall be deemed to affect the otherwise lawful right of a ~~mineral owner~~ person to drill or bore through or to otherwise exercise rights near a carbon dioxide sequestration ~~site~~ facility, if done in accordance with the rules promulgated under this article for protecting the carbon dioxide sequestration ~~site~~ facility against the escape of carbon dioxide.

(b) Nothing in this article is intended to impede or impair the ability of an oil, natural gas or coalbed methane operator to inject carbon dioxide through an approved enhanced oil, natural gas or coalbed methane recovery project and to establish, verify, register and sell emission reduction credits associated with the project.

(c) The ~~Office of Oil and Gas~~ secretary shall have jurisdiction over any subsequent extraction of sequestered carbon dioxide that is intended for commercial or industrial purposes.

(d) Except as herein specifically provided, nothing in this article shall alter or amend existing state law regarding correlative property rights or the primacy of the oil, natural gas, coal, coalbed methane or other mineral estate.

(e) Title to the carbon dioxide injected into and stored in a carbon dioxide sequestration facility is vested in the owner or operator of such facility, and such owner or operator retains title throughout the operational life of such facility, and until the secretary issues a certificate of completion.

(f) Once the secretary has issued a certificate of completion, title to the carbon dioxide sequestered in a carbon dioxide sequestration facility transfers to the owner of the right to use the reservoir unless that owner cannot be determined in which case title to such carbon dioxide transfers to the owner of the surface estate.

(g) Any extraction for profit of carbon dioxide sequestered in a carbon dioxide sequestration facility shall be undertaken only with the agreement of the owner of the right to use the reservoir or the owner of the surface estate in the event the owner of the right to use the reservoir cannot be determined. Any extraction of carbon dioxide sequestered in a carbon dioxide sequestration facility for the purpose of remediation or for the protection of human health or the environment may be undertaken without the agreement of such owner.

(h) Except as herein specifically provided, nothing in this article shall alter, amend, diminish or invalidate rights to use a reservoir that was acquired by contract or lease prior to the effective date of this article, including, without limitation, rights acquired for the underground storage of natural gas, or in connection with the extraction or production of oil, natural gas, coal, coalbed methane or other minerals, including, without limitation, rights for the secondary recovery of coal, oil, natural gas, coalbed methane or other minerals by injection of carbon dioxide or water or by other means.

5. Amalgamation of Property Rights

To the extent that it is necessary for an operator to take an interest in property, the issuance of a permit under this article in conjunction with PSC approval shall be sufficient to authorize the amalgamation of property rights. Existing powers of eminent domain are to be preserved. In determining the amount of compensation to be paid to a property owner for the taking of any necessary property rights related to the use of pore space, no value shall be attributed to the present or future use of that pore space for the sequestration of CO_2. One additional option for streamlining the process of undertaking eminent domain would be to rely upon tax records to determine property ownership.

Proposed new section:

§22-11A-8. Amalgamation of property rights.

(a) Except as provided in subsection (b) of this section, any owner or operator of an existing or proposed carbon dioxide sequestration facility or carbon dioxide transmission pipeline is hereby authorized to exercise the power of eminent domain or to request a pooling order pursuant to this section to acquire surface and subsurface property rights as may be necessary or useful for the purpose of constructing, operating or modifying a carbon dioxide sequestration facility or carbon dioxide transmission pipeline, including easements and rights-of-way across lands for pipelines transporting carbon dioxide to and among facilities constituting said carbon dioxide sequestration facility.

(b) No owner or operator of a carbon dioxide sequestration facility or carbon dioxide transmission pipeline may exercise the power of eminent domain or request a pooling order granted in this section:

(1) to obtain the right to inject carbon dioxide into a portion of a geologic formation bearing oil, natural gas, coal, coalbed methane, or other mineral which on the effective date of any permit from the secretary required by this article is of such quantity and quality as to justify commercial production of that oil, natural gas, coal, coalbed methane, or other mineral;

(2) to obtain the right to inject carbon dioxide into a portion of a geologic formation located at a depth of less than two thousand five hundred feet below the surface;

(3) to obtain right of way for a pipeline to transport carbon dioxide that is withdrawn from a carbon dioxide sequestration facility to a location that is outside the boundaries of such facility; or

(4) to obtain any rights or interests in a carbon dioxide sequestration facility subject to a permit issued pursuant to this article or subject to a cooperative agreement pursuant to section eighteen of this article.

(c) The eminent domain authority authorized by this article shall be conducted pursuant to the provisions of article two, chapter fifty-four of this code.

(d) The pooling of property rights authorized by this section shall be initiated by filing with the secretary an application for an order requesting the pooling of such property rights; provided, that the applicant for pooling shall

(1) in the case of a carbon dioxide sequestration facility, own or control required property rights of at least sixty percent of the acreage (calculating partial interests on a pro rata basis for interests on any parcel owned in common) in the reservoir within the area covered or to be covered by a permit issued pursuant to this article. Any interests owned by abandoning, missing or unknown heirs shall be excluded from the calculation of such sixty percent requirement; and

(2) in the case of a carbon dioxide transmission pipeline, own or control required property rights of at least sixty percent of the acreage (calculating partial interests on a pro rata basis for interests on any parcel owned in common) in the right of way covered or to be covered by a certificate of public convenience and necessity pursuant to this section eleven, article two, chapter twenty-four of this code. Any interests owned by abandoning, missing or unknown heirs shall be excluded from the calculation of such sixty percent requirement.

(e) The secretary shall set a hearing and provide notice to all interested parties in accordance with section four of this article with respect to a request for pooling. Each notice shall describe the area for which an order is to be entered in recognizable, narrative terms; contain such other information as is essential to the giving of proper notice, including the time and date and place of a hearing. After the hearing and upon a determination that the requirements of this section have been satisfied, the secretary shall enter an order pooling the subject property rights, authorizing the requested usage, and in the absence of a written agreement, making provisions for payment of compensation to the owners of the subject property rights upon such terms as the secretary determines is reasonable. The basis for such compensation shall be set forth in the order. The owner of the subject property rights may elect to sell its property rights by delivering a written notice to the owner of the carbon dioxide sequestration facility or carbon dioxide transmission pipeline within thirty days after entry of a pooling order pursuant to this section. In the absence of an agreement on the price to be paid, the secretary shall establish the price after notice and opportunity for hearing. Any such election or hearing shall not delay the effectiveness of the pooling order. The secretary shall enter an order granting the request for pooling, dismissing the application, or for good cause, continuing the application process within forty-five days after the filing of an application.

(f) The right of eminent domain or pooling set out in this section shall not prejudice the rights of the owners of other rights or interests therein as to all other uses not acquired for the carbon dioxide sequestration facility or carbon dioxide transmission pipeline.

(g) The eminent domain authority authorized under this section shall be in addition to any other power of eminent domain authorized by law.

(h) Notwithstanding any other provision of this code to the contrary, with respect to a condemnation petition filed in a circuit court pursuant to the provisions of this section or an application for pooling filed with the secretary pursuant to the provisions of this section, it shall be sufficient for the applicant to file the petition or application, as appropriate, against one or more parcels of land, or interests therein, and to serve notice of the action upon those persons and entities listed in the sheriff's tax records as the owners of the surface and mineral estates in the affected property, updated by examination of documents duly recorded in the office of the clerk of the county commission only from the date of the last tax assessment. Service upon out-of-state residents shall be sufficient if mailed to the address shown in the tax records, as updated, by first class mail, postage pre-paid. An affidavit of service or other proof of service shall be filed as a part of the record of the condemnation or pooling action, as appropriate. The applicant shall also publish notice of the action as a Class 1 legal advertisement in a newspaper of general circulation in county or counties in which affected property is located. The proofs of service and proof of publication shall be filed as a part of the record of the condemnation or pooling action, as appropriate. Any person or entity not served but claiming an interest in any of the properties may intervene within thirty days after publication of the notice and assert a claim. No applicant following this procedure shall have any liability on account of the condemnation or pooling, as appropriate, to any person or entity not listed in the sheriff's tax records, updated only as aforesaid, or not intervening in the condemnation or pooling proceedings, as appropriate.

(i) The request for pooling may be filed concurrently with an application for or subsequent to issuance of a permit from the secretary required by this article A certified copy of any order authorizing pooling shall be recorded by the applicant in the office of the clerk of the county commission of each county in which property rights are pooled.

(j) The power of eminent domain may be exercised after obtaining any permit from the secretary required by this article and any certificate of public convenience and necessity from the public service commission as provided in section eleven-e, article two, chapter twenty-four of this code.

§54-1-2. Public uses for which private property may be taken or damaged.

(a) The public uses for which private property may be taken or damaged are as follows:

(1) For the construction, maintenance and operation of railroad and traction lines (including extension, lateral and branch lines, spurs, switches and sidetracks), canals, public landings, wharves, bridges, public roads, streets, alleys, parks and other works of internal improvement, for the public use;

(2) For the construction and maintenance of telegraph, telephone, electric light, heat and power plants, systems, lines, transmission lines, conduits, stations (including branch, spur and service lines), when for public use;

(3) For constructing, maintaining and operating pipelines, plants, systems and storage facilities for manufacturing gas and for transporting petroleum oil, natural gas, manufactured gas, and all mixtures and combinations thereof, by means of pipes, pressure stations or otherwise, (including the construction and operation of telephone and telegraph lines for the service of such systems and plants), and for underground storage areas and facilities, and the operation and maintenance thereof, for the injection, storage and removal of natural gas in subterranean oil and/or gas bearing stratum, which, as shown by previous exploration of the stratum sought to be condemned and within the limits of the reservoir proposed to be utilized for such purposes, has ceased to produce or has been proved to be nonproductive of oil and/or gas in substantial quantities, when for public use, the extent of the area to be acquired for such purpose to be determined by the court on the basis of reasonable need therefore. Nothing in this subsection shall be construed to

interfere with the power of the state and its political subdivisions to enact and enforce ordinances and regulations deemed necessary to protect the lives and property of citizens from the effects of explosions of oil or gas;

(4) For carbon sequestration facilities and carbon dioxide transmission pipelines in accordance with the provisions of section eight, article eleven-a, chapter twenty-two of this code.

6. Inverse Condemnation.

If at any time a property owner should become concerned that there has been a per se physical taking of property rights, the property owner should be allowed to bring an inverse condemnation action to recover just compensation under the Constitution. This would be the owners exclusive recourse. The operator would not be subject to common law claims for damages or otherwise in such event.

Proposed new section:

§22-11A-9. Inverse condemnation; common law claims.

The sole remedy of the owner of a property right who claims that the use of such property right by a carbon dioxide sequestration facility is a per se physical taking of property without just compensation shall be to file an inverse condemnation action to obtain just compensation. In such event, the operator shall not be liable under common law for trespass, nuisance, or any other common law claim.

7. Role of ALJs

As an alternative to filing an eminent domain action in circuit court, it may be desirable to allow application to be made to a special panel of administrative law judges or special board of appraisers empowered to determine compensation to be paid for property rights to be taken (subject to appeal to an appropriate circuit court).

8. Permitting by the PSC

A certificate of public convenience and necessity may be required from the PSC before beginning construction of the sequestration facility or carbon dioxide transmission pipeline. Any sequestration operator or pipeline operator who obtains a permit under the West Virginia Carbon Dioxide Sequestration Act and obtains a certificate of public convenience and necessity from the PSC (other than a "private operator" providing service only to an identified person or persons) shall be authorized to exercise the power of eminent domain pursuant to the provisions of Chapter 54 of this Code. It is proposed that a new section of code, designated W. Va. Code § 24-2-11e, as well as amendments to §§ 24-2-1 (on PSC jurisdiction) and 54-1-2 (on eminent domain), be undertaken. Three types of entities are anticipated: (i) a pure "public utility" providing capacity or service on an open-access basis pursuant to PSC-established rates; (ii) a "certified private operator" providing service or capacity at negotiated rates to one or more identified parties; and a (iii) "private operator" providing the same type of service as a "certified private operator," but with no obligation to obtain PSC certification. Public utilities and certified private operators would be required to submit to the Certificate of Public Convenience and Necessity ("CPCN") process, and each would benefit from eminent domain authority; private operators would have no such authority.

It is also necessary to discuss the intrastate and interstate transport of CO_2. Once CO_2 has been captured there are several ways to transport it. These CO_2 transportation methods include pipelines, tanker or railway car, ship and road. According to International Energy Agency's (IEA) November 2010 "Carbon Capture and Storage Model Regulatory Framework" Information Paper, there are several regulatory considerations for CO_2 transportation including:

- Health, safety, civil and environmental protection in the event of CO_2 releases during transportation;
- Allocation of liability in the event of damage resulting from CO_2 releases;
- Pipeline re-use, routing/corridor requirements and acquisition of rights-of-way;
- Accounting for fugitive emissions in a project's emissions inventory; and
- Third-party access to CO_2 transportation networks.

IEA, *Carbon Capture and Storage Model Regulatory Framework Information Paper*, Nov. 2010, at 51.

Siting

There are approximately 4,000 miles of CO_2 pipelines in the United States. These pipelines have primarily been constructed for use of CO_2 in enhanced oil recovery operations. The pipelines were built as open access, closed access, interstate and intrastate private sector business models with limited federal government regulation on funding. The states have provided the siting, construction, operation, and economic regulation of these CO_2 pipelines. The regulatory authority for future CO_2 pipeline siting decisions should consider the chemical properties of CO_2 and potential risks to human health and the environment.

Certificate of need

CO_2 pipeline operators need to consult with the states to determine whether a certificate of need can be obtained. The federal government is not involved in this process. As an example of a state requirement for having a certificate of need for public utilities, although not necessarily CO_2 transport, the Public Service Commission for the state of Minnesota described the purpose of having a requirement for Certificate of Need for large energy projects:

> The Certificate of Need process was designed to evaluate the need for a large energy project in Minnesota. The evaluation is to determine whether or not as well as the alternative (including no-build) available to satisfy that need. Simply stated, in the need process, the Commission determines the basic types of facility (if any) to be constructed, the size of the facility and the timing of the facility (e.g. when projected to be in service). The process typically takes twelve months to complete.

Minnesota Public Service Commission, *Certificate of Need*, available at http://www.puc.state.mn.us/puc/energyfacilities/certificate-of-need/con.html. A similar scheme may be required by individual states for CO_2 transportation.

Right of way acquisition

Acquiring a right of way across public and private property is necessary for the development and construction of CO_2 pipelines. Currently the federal government only regulates right of way acquisition across federal lands. States independently regulate right of way acquisition. Condemnation rights are also state-specific.

Safety

The chemical properties of the CO_2 being transported through CO_2 pipelines are an important safety consideration. IEA, *Carbon Capture and Storage Model Regulatory Framework Information Paper*, Nov. 2010, at 52. When other substances are present in the CO_2 stream it can affect the chemical properties of CO_2. For example, if water is present in the CO_2 stream it can mix with the CO_2 to form carbonic acid which is corrosive to mild steel and may risk pipeline integrity. Thus care must be taken to prevent water from mixing with the CO_2. Another consideration of the chemical properties of the CO_2 is that the temperature of CO_2 decreases as CO_2 expands, which may cause freezing of materials that come in contact with the CO_2. *Id.* CO_2 transportation also faces many of the same liability and risk issues associated with CO_2 sequestration. If the CO_2 is released into the environment, it may adversely affect human health and the environment. This is due to the high vapor density of CO_2 that can cause it to remain low to the ground and potentially result in asphyxiation. IEA, *Carbon Capture and Storage Model Regulatory Framework Information Paper*, Nov. 2010, at 52. The federal government currently regulates CO_2 pipeline safety. CO_2 pipelines are regulated to the same degree as hazardous liquids pipelines by the U.S. Dept. of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA), pursuant to the Hazardous Liquid Pipeline Act of 1979 (HLPA). 49 U.S.C. § 601. Due to the specific chemical nature of CO_2 certain monitoring requirements are necessary to protect human health and the environment.

Alternatives

CCSReg in its "Policy Brief: Regulating Carbon Dioxide Pipelines for the Purpose of Transporting Carbon Dioxide to Geologic Sequestration Sites" suggests a federal approach to the regulation of CO_2 pipelines in its recommendations:

- Create an "opt-in" federal regime that provides the Federal Energy Regulatory Commission (FERC) with authority to consider and grant or deny applications for federal siting permits for new CO_2 pipelines built to transport CO_2 for purposes of permanent sequestration. The federal siting permit should provide the pipeline with federal eminent domain authority.
- Once new CO_2 pipelines with federal siting permits are operational they should be subject to non-discriminatory access and rate regulation. Prescriptive cost-of-service rate regulation is not necessary.
- Retain the current system of state siting and economic regulation for existing CO_2 pipelines. New CO_2 pipelines would also be subject to the current system unless they opt into

the federal regulatory regime by filing for and obtaining a federal siting permit.

- Streamline the permitting process for CO_2 pipeline projects on federal lands.
- Utilize the existing pipelines safety regulatory framework to ensure safe operation of all CO_2 pipelines.

The IOGCC and the Southern States Energy Board are in the final stages of the issuance of a topical report on the subject that is expected to issue recommendations on the relationship between federal policy and the market driven demand.

Some of these CO_2 transport considerations have been built into the following PSC provisions.

§24-2-1. Jurisdiction of commission; waiver of jurisdiction.

(a) The jurisdiction of the commission shall extend to all public utilities in this state and shall include any utility engaged in any of the following public services:

Common carriage of passengers or goods, whether by air, railroad, street railroad, motor or otherwise, by express or otherwise, by land, water or air, whether wholly or partly by land, water or air; transportation of oil, gas or water by pipeline; <u>transportation of carbon dioxide by pipeline to carbon dioxide sequestration facilities, or sequestration of carbon dioxide in reservoirs, or both; in any such case when for public use or when engaged in by a certified private operator, as defined in subdivision (4), subsection (j), section eleven-e of this article</u>; transportation of coal and its derivatives and all mixtures and combinations thereof with other substances by pipeline; sleeping car or parlor car services; transmission of messages by telephone, telegraph or radio; generation and transmission of electrical energy by hydroelectric or other utilities for service to the public, whether directly or through a distributing utility; supplying water, gas or electricity, by municipalities or others; sewer systems servicing twenty-five or more persons or firms other than the owner of the sewer systems: Provided, That if a public utility intends to provide sewer service by an innovative, alternative method, as defined by the Federal Environmental Protection Agency, the innovative, alternative method is a public utility function and subject to the jurisdiction of the Public Service Commission regardless of the number of customers served by the innovative, alternative method; any public service district created under the provisions of article thirteen-a, chapter sixteen of this code; toll bridges, wharves, ferries; solid waste facilities; and any other public service: Provided, however, That natural gas producers who provide natural gas service to not more than twenty-five residential customers are exempt from the jurisdiction of the commission with regard to the provisions of such residential service: Provided further, That upon request of any of the customers of such natural gas producers, the commission may, upon good cause being shown, exercise such authority as the commission may deem appropriate over the operation, rates and charges of such producer and for such length of time as the commission may consider to be proper: And provided further, That the jurisdiction the commission may exercise over the rates and charges of municipally operated public utilities is limited to that authority granted the commission in section four-b of this article: And provided further, That the decision-making authority granted to the commission in sections four and four-a of this article shall, in respect to an application filed by a public service district, be delegated to a single hearing examiner appointed from the commission staff, which hearing examiner shall be authorized to carry out all decision-making duties assigned to the commission by said sections, and to issue orders having the full force and effect of orders of the commission.

(b) The commission may, upon application, waive its jurisdiction and allow a utility operating in an adjoining state to provide service in West Virginia when:

(1) An area of West Virginia cannot be practicably and economically served by a utility licensed to operate within the State of West Virginia;

(2) Said area can be provided with utility service by a utility which operates in a state adjoining West Virginia;

(3) The utility operating in the adjoining state is regulated by a regulatory agency or commission of the adjoining state; and

(4) The number of customers to be served is not substantial. The rates the out-of-state utility charges West Virginia customers shall be the same as the rate the utility is duly authorized to charge in the adjoining jurisdiction. The commission, in the case of any such utility, may revoke its waiver of jurisdiction for good cause.

(c) Any other provisions of this chapter to the contrary notwithstanding:

(1) An owner or operator of an electric generating facility located or to be located in this state that has been designated as an exempt wholesale generator under applicable federal law, or will be so designated prior to commercial operation of the facility, and for which such facility the owner or operator holds a certificate of public convenience and necessity issued by the commission on or before the first day of July, two thousand three, shall be subject to subsections (e), (f), (g), (h), (i) and (j), section eleven-c of this article as if the certificate of public convenience and necessity for such facility were a siting certificate issued under said section and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility except for the making or constructing of a material modification

thereof as provided in subdivision (5) of this subsection.

(2) Any person, corporation or other entity that intends to construct or construct and operate an electric generating facility to be located in this state that has been designated as an exempt wholesale generator under applicable federal law, or will be so designated prior to commercial operation of the facility, and for which facility the owner or operator does not hold a certificate of public convenience and necessity issued by the commission on or before the first day of July, two thousand three, shall, prior to commencement of construction of the facility, obtain a siting certificate from the commission pursuant to the provisions of section eleven-c of this article in lieu of a certificate of public convenience and necessity pursuant to the provisions of section eleven of this article. An owner or operator of an electric generating facility as is described in this subdivision for which a siting certificate has been issued by the commission shall be subject to subsections (e), (f), (g), (h), (i) and (j), section eleven-c of this article and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility except for the making or constructing of a material modification thereof as provided in subdivision (5) of this subsection.

(3) An owner or operator of an electric generating facility located in this state that had not been designated as an exempt wholesale generator under applicable federal law prior to commercial operation of the facility, that generates electric energy solely for sale at retail outside this state or solely for sale at wholesale in accordance with any applicable federal law that preempts state law or solely for both such sales at retail and such sales at wholesale, and that had been constructed and had engaged in commercial operation on or before the first day of July, two thousand three, shall not be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility, regardless of whether such facility subsequent to its construction has been or will be designated as an exempt wholesale generator under applicable federal law: *Provided,* That such owner or operator shall be subject to subdivision (5) of this subsection if a material modification of such facility is made or constructed.

(4) Any person, corporation or other entity that intends to construct or construct and operate an electric generating facility to be located in this state that has not been or will not be designated as an exempt wholesale generator under applicable federal law prior to commercial operation of the facility, that will generate electric energy solely for sale at retail outside this state or solely for sale at wholesale in accordance with any applicable federal law that preempts state law or solely for both such sales at retail and such sales at wholesale and that had not been constructed and had not been engaged in commercial operation on or before the first day of July, two thousand three, shall, prior to commencement of construction of the facility, obtain a siting certificate from the commission pursuant to the

provisions of section eleven-c of this article in lieu of a certificate of public convenience and necessity pursuant to the provisions of section eleven of this article. An owner or operator of an electric generating facility as is described in this subdivision for which a siting certificate has been issued by the commission shall be subject to subsections (e), (f), (g), (h), (i) and (j), section eleven-c of this article and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility except for the making or constructing of a material modification thereof as provided in subdivision (5) of this subsection.

(5) An owner or operator of an electric generating facility described in this subsection shall, before making or constructing a material modification of the facility that is not within the terms of any certificate of public convenience and necessity or siting certificate previously issued for the facility or an earlier material modification thereof, obtain a siting certificate for the modification from the commission pursuant to the provisions of section eleven-c of this article in lieu of a certificate of public convenience and necessity for the modification pursuant to the provisions of section eleven of this article and, except for the provisions of section eleven-c of this article, shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such modification.

(6) The commission shall consider an application for a certificate of public convenience and necessity filed pursuant to section eleven of this article to construct an electric generating facility described in this subsection or to make or construct a material modification of such electric generating facility as an application for a siting certificate pursuant to section eleven-c of this article if the application for the certificate of public convenience and necessity was filed with the commission prior to the first day of July, two thousand three, and if the commission has not issued a final order thereon as of that date.

(7) The limitations on the jurisdiction of the commission over, and on the applicability of the provisions of this chapter to, the owner or operator of an electric generating facility as imposed by, and described in this subsection, shall not be deemed to affect or limit the commission's jurisdiction over contracts or arrangements between the owner or operator of such facility and any affiliated public utility subject to the provisions of this chapter.

(d) Any other provisions of this chapter to the contrary notwithstanding, any person, corporation, or other entity that has been determined by the commission to be a "certified private operator" as defined in subdivision (4), subsection (j), section eleven-e of this article, shall be subject to subsection (g), section eleven-e of this article and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility. The limitations on the jurisdiction of the commission over, and on the applicability of the provisions of this chapter to, a certified private operator, as imposed by and described in this subsection, shall not be deemed to affect or limit the commission's jurisdiction over contracts or arrangements between the certified private operator and any affiliated public utility subject to the provisions of this chapter.

§24-2-11e. Certificates of public convenience and necessity for carbon dioxide sequestration facilities or carbon dioxide transmission pipelines.

(a) Any public utility, person, or corporation that wishes to own or operate a carbon dioxide sequestration facility or carbon dioxide transmission pipeline as a public utility or a certified private operator shall obtain from the commission a certificate of public convenience and necessity approving the construction and proposed location of such facility prior to construction of such facility. Any prior operator wishing to own or operate such a facility as a public utility or a certified private operator shall be deemed to have a certificate of public convenience and necessity; provided, that any such prior operator shall be required, within ninety days of the effective date of this section, to apply for approval of the terms and conditions on which service or capacity of the facility will be provided, including whether the applicant seeks approval to provide service or capacity as a certified private operator.

(b) An application filed under subsection (a) of this section shall be in such form as the commission may prescribe and shall contain:

(1) A description, in such detail as the commission may prescribe, of the general location and type of carbon dioxide sequestration facility or carbon dioxide transmission pipeline which the applicant proposes to construct;

(2) A statement justifying the need for the facility;

(3) A description of the terms and conditions on which service or capacity of the facility will be provided, including whether the applicant proposes to provide service as a certified private operator; and

(4) Such other information as the applicant may deem relevant or the commission may require by rule.

(c) Upon the filing of such application, the applicant shall publish, in such form as the commission shall direct, as a Class I legal advertisement in compliance with the provisions of article three, chapter fifty-nine of this code, the publication area for such publication to be each county in which any portion of the proposed carbon dioxide sequestration facility or carbon dioxide transmission pipeline is to be constructed or located, a notice of the filing of such application. The commission may approve the application unless within fifteen days after completion of publication a written request for a hearing thereon has been received by the commission from a person or persons alleging that certification of the facility or its location is against the public interest. If such request be timely received and the commission determines that the issues raised in the protest cannot be effectively addressed without a hearing, the commission shall set the matter for hearing, and shall require the applicant to publish notice of the time and place of hearing in the same manner as is herein required for the publication of notice of the filing of the application.

(d) The commission shall approve the application if it shall find and determine that the construction and operation of the proposed carbon dioxide sequestration facility or carbon dioxide transmission pipeline (i) will economically, adequately and reliably contribute to meeting the present and anticipated requirements for the sequestration or transportation of carbon dioxide; and (ii) is otherwise convenient and necessary under the circumstances.

(e) The commission shall make any order approving the construction and operation of such a facility contingent upon the applicant's having obtained the necessary permits and authorizations, if any, from the department of environmental protection and any other state and federal agencies having jurisdiction. The commission's jurisdiction over the potential environmental impacts of such a facility shall be limited to requiring that the applicant obtain such permits and authorizations prior to commencing operation of the facility. The commission may include other reasonable conditions in its order approving the construction and operation of such a facility.

(f) The commission shall render its final decision on any application for a certificate of public convenience and necessity filed under the provisions of this section within three hundred days of the filing of the application. If no decision is rendered within such time period, the commission shall issue a certificate as applied for. The commission shall render its final decision on any application for approval filed pursuant to the second sentence of subsection (a) of this section, or any application by a private operator for authority to provide service or capacity pursuant to subsections (h) or (i) of this section, within one hundred fifty days of the filing of the application. If no decision is rendered within such time period, the commission shall issue an order granting the relief requested as applied for.

(g) The commission shall have continuing jurisdiction over any certified private operator, for the limited purposes of: (1) Considering future requests for modification of or amendments to the certificate; (2) considering and resolving complaints related to compliance with the material terms and conditions of the commission order issuing the certificate; and (3) enforcing the material terms and conditions of any commission order issuing or modifying the certificate.

(h) No private operator shall provide service or capacity from a carbon dioxide sequestration facility or carbon dioxide transmission pipeline to the public on an open-access, non-discriminatory basis until the commission has approved the terms and conditions upon which service or capacity of the facility will be provided and certified the private operator as a public utility with respect to the carbon dioxide sequestration facility or carbon dioxide transmission pipeline. In any application for such certification under this section, the commission may require such information about the private operator's operations and existing facilities as it may determine by rule. The commission may refuse to certify any such private operator as a public utility if it reasonably determines that the private operator willfully evaded the obligation to obtain a certificate of public convenience and necessity for such carbon dioxide sequestration facility or carbon dioxide transmission pipeline by initially electing to construct such facilities as a private operator and then seeking certification as a public utility with respect to such facilities.

(i) No private operator shall provide service or capacity from a carbon dioxide sequestration facility or carbon dioxide transmission pipeline as a certified private operator unless and until it has been certified as a certified private operator by the commission under this section. In any application for such certification under this section, the commission may require such information about the private operator's operations and existing facilities as it may determine by rule. The commission may refuse to certify any such private operator as a certified private operator if it reasonably determines that the private operator willfully evaded the obligation to obtain a certificate of public convenience and necessity for such carbon dioxide sequestration facility or carbon dioxide transmission pipeline by initially electing to construct such facilities as a private operator and then seeking certification as a certified private operator with respect to such facilities.

(j) As used in this section, the following words and phrases shall have the following meanings:

(1) "Carbon dioxide sequestration facility" shall have the same meaning as defined in article eleven-a, chapter twenty-two of this code.

(2) "Carbon dioxide transmission pipeline" shall have the same meaning as defined in article eleven-a, chapter twenty-two of this code.

(3) "Certified private operator" means an entity that, pursuant to commission authority under this section, operates a carbon dioxide sequestration facility or carbon dioxide transmission pipeline for the purpose of providing service or capacity at negotiated rates and charges to one or more identified persons approved by the commission, and which does not and does not intend to provide service or capacity from such facility on an open-access, non-discriminatory basis. Upon commission certification, a certified private operator may exercise the rights set forth

in sections eight and nine, article eleven-a, chapter twenty-two of the code and section two, article one, chapter fifty-four of the code.

(4) "Prior operator" means any entity owning or operating a carbon dioxide sequestration facility or carbon dioxide transmission pipeline in existence and in operation on the effective date of this section to the extent that such facility has received all permits and approvals from the department of environmental protection required for the initial construction and operation of the facility.

(5) "Private operator" means an entity that operates a carbon dioxide sequestration facility or carbon dioxide transmission pipeline for the purpose of providing service or capacity at negotiated rates and charges to one or more identified persons, which does not and does not intend to provide service or capacity from such facility on an open-access, non-discriminatory basis, and which has not exercised and does not intend to exercise any of the rights set forth in sections eight and nine, article eleven-a, chapter twenty-two of the code or section two, article one, chapter fifty-four of the code. A private operator is not a public utility and is not authorized to provide any service or capacity for public use.

(k) The commission may prescribe such rules as may be necessary to carry out the provisions of this section in accordance with the provisions of section seven, article one of this chapter.

CHAPTER 24B. GAS AND PIPELINE SAFETY.

ARTICLE 1. PURPOSE AND DEFINITIONS.

§ 24B-1-1. Purpose.

It is hereby declared to be the purpose and policy of the legislature in enacting this chapter to empower the public service commission of West Virginia, in addition to all other powers conferred and duties imposed upon it by law, to prescribe and enforce safety standards for pipeline facilities as hereinafter defined, and to regulate safety practices of persons engaged in the transportation of gas or hazardous liquids as hereinafter defined.

§ 24B-1-2. Definitions.

When used in this chapter:

(1) "Person" means any individual, firm, joint venture, partnership, corporation, association, state, municipality, cooperative association or joint-stock association, and includes any trustee, receiver, assignee or personal representative thereof;

(2) "Gas" means natural gas, carbon dioxide in a gaseous state, flammable gas or gas which is toxic or corrosive;

(3) "Transportation of gas" means the gathering, transmission or distribution of gas by pipeline or its storage;

(4) “Hazardous liquid” means:

(a) Petroleum or any petroleum product;

(b) Carbon dioxide in any physical state, and

(c) Any substance or material which is in liquid state (excluding liqu~~i~~efied natural gas) when transported by pipeline facilities and which, as determined by the commission, may pose an unreasonable risk to life or property when transported by pipeline facilities: Provided, That a hazardous liquid as herein defined shall not be construed so as to include or permit the regulation of any substance transported through pipeline or otherwise when used in the operation of coal mines, coal processing plants or coal slurry pipelines: Provided, however, That the commission shall not determine that any substance or material is a hazardous liquid under this section if the secretary has not determined that the substance or material is a hazardous liquid under regulations promulgated in accordance with Section 202(2) of the Hazardous Liquid Pipeline Safety Act of 1979;

(5) “Transportation of hazardous liquids” means the movement of hazardous liquids by pipeline, or their storage incidental to such movements; except that it shall not include any such movement through gathering lines in rural locations or on shore production, refining or manufacturing facilities or storage or in-plant piping systems associated with any of such facilities;

(6) “Pipeline facilities” means, without limitation, new and existing pipe, pipe rights-of-way and any equipment, facility, or building used in the transportation of gas or the treatment of gas during the course of transportation, or used in the transportation of hazardous liquid or the treatment of hazardous liquid during the course of transportation; but “rights-of-way” as used in this chapter does not authorize the commission to prescribe the location or routing of any pipeline facility;

(7) “Municipality” means a city, county or any other political subdivision of the state;

(8) “Interstate transmission facilities” means facilities used in the transportation of gas which are subject to the jurisdiction of the federal power commission under the act of Congress known as the Natural Gas Act;

(9) “Interstate pipeline facilities” means the pipeline facilities used in the transportation of hazardous liquids in interstate or foreign commerce;

(10) “Director” means the director of the gas pipeline safety section of the commission;

(11) “Commission” means the public service commission of West Virginia;

(12) "Secretary" means the United States of transportation;

(13) "Pipeline company" means a person engaged in the operation of pipeline facilities or the transportation of gas or hazardous liquids subject to the provisions of this chapter;

(14) "Act of 1968" means the act of Congress known as the Natural Gas Pipeline Safety Act of 1968; and

(15) "Act of 1979" means the act of Congress known as the "Hazardous Liquid Pipeline Safety Act of 1979."

§ 24B-2-1. Jurisdiction.

The commission shall have power and authority to prescribe and enforce safety standards for pipeline facilities, and to regulate safety practices of persons engaged in the transportation of gas or hazardous liquids, to the extent permitted by the "Act of 1968" and the "Act of 1979" and any amendments thereto, and to regulate safety practices of persons engaged in the transportation of carbon dioxide, provided, however, that no such safety standards or safety practices shall be more stringent than any comparable federal requirements if any exist. Such standards may apply to the design, installation, inspection, testing, construction, extension, operation, replacement and maintenance of pipeline facilities. Standards affecting the design, installation, construction, initial inspection and initial testing shall not be applicable to pipeline facilities in existence on the date such standards are adopted. Whenever the commission shall find a particular facility to be hazardous to life or property, it shall be empowered to require the person operating such facility to take such steps necessary to remove such hazards. Such safety standards shall be practicable and designed to meet the need for pipeline safety. In prescribing such standards, the commission shall consider:

(a) Relevant available pipeline safety data;

(b) Whether such standards are appropriate for the particular type of pipeline transportation;

(c) The reasonableness of any proposed standards; and

(d) The extent to which such standards will contribute to public safety.

10. Groundwater Protection

The Groundwater Protection Act currently contains exemptions for activities that involve direct contact with groundwater. At the time the Groundwater Protection Act was enacted in 1994, the possibility of injecting carbon dioxide in geologic formations was not known to the Legislature. Since carbon sequestration is very similar to the activities that were exempt from coverage under various portions of the Groundwater Protection Act, it is appropriate to expand those exemptions to include carbon dioxide sequestration wells in the same manner that UIC Class 2 and 3 wells are currently exempt.

§22-12-5. Authority of other agencies; applicability.

(i) This article is not applicable to groundwater within those portions of geologic formations which are site specific to:

(1) The production or storage zones of crude oil or natural gas and which are utilized for the exploration, development or production of crude oil or natural gas permitted pursuant to articles six, seven, eight, nine or ten of this chapter; and

(2) The injection zones of Class II, ~~or~~ III, or VI wells permitted pursuant to the statutes and rules governing the underground injection control program.

(3) The injection zones of all other wells otherwise permitted pursuant to the statutes and rules governing carbon sequestration.

All groundwater outside such areas remain subject to the provisions of this article. Groundwater regulatory agencies have the right to require the submission of data with respect to the nature of the activities subject to this subsection.

Editorial Note: While we understand that coalbed methane is not within the context of CCS we believe paragraph 22-12-5(i)(1) should be modified to include coalbed methane.

11. Report to Legislature

The secretary and the carbon dioxide management authority shall submit timely reports to the legislature assessing the effectiveness of the carbon dioxide sequestration program and the administration of the funds.

§22-11A-19. Reporting and accountability.

(a) Every five years the secretary shall submit a report to the Legislature which assesses the effectiveness of this article and provides such other information as may be requested by the Legislature to allow the Legislature to assess the effectiveness of this article, including without limitation ~~The department shall include within the reports to the Legislature required by section six, article twelve of this chapter its~~ the secretary's observations concerning all aspects of compliance with this article, ~~including without limitation~~ the promulgation of rules, ~~the formation of the carbon dioxide sequestration working group,~~ the permitting process and any pertinent changes to federal rules or regulations.

(b) The secretary shall keep accurate accounts of all receipts and disbursements related to the administration of the carbon dioxide sequestration facility operational fund and shall make a specific annual report addressing the administration of the fund.

(c) The authority shall keep accurate accounts of all receipts and disbursements related to the administration of the carbon dioxide sequestration facility post-closure trust fund and shall make a specific annual report addressing the administration of the fund.

12. Liability

Certain limitations on liability are appropriate during the operational phase of a project. In addition, there will be a multistep process for liability transfer, which will only occur after 10 years post-closure after WVDEP has determined that the facility does not leak in addition to meeting other regulatory requirements. This liability transfer should be authorized during the post-closure period to promote CCS activities. To assure that the operator bears responsibility for post-closure liabilities, the operator will be required to fund a trust fund in an amount that is actuarially determined to be adequate to respond to the risks the facility may create. Ownership of the sequestration facility shall transfer to a quasi-public entity or the federal government upon the issuance of a certificate of completion by the secretary of the WVDEP.

§22-11A-12. **Limitations on claims and liabilities during the operational phase**.

(a) In any civil liability action against the owner or operator of a carbon dioxide sequestration facility, or carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, the maximum amount recoverable as compensatory damages for noneconomic loss shall not exceed two hundred fifty thousand dollars per occurrence, except where the damages for noneconomic loss suffered by the plaintiff were for: (1) wrongful death; (2) permanent and substantial physical deformity, loss of use of a limb or loss of a bodily organ system; or (3) permanent physical or mental functional injury that permanently prevents the injured person from being able to independently care for himself or herself and perform life sustaining activities. In such cases, the maximum amount recoverable as compensatory damages for noneconomic loss shall not exceed five hundred thousand dollars per occurrence.

(b) If subsection (a) of this section, or the application thereof to any person or circumstance, is found by a court of law to be unconstitutional or otherwise invalid, the maximum amount recoverable as damages for noneconomic loss under either subsection shall thereafter not exceed one million dollars per occurrence.

(c) In any civil liability action against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, punitive damages cannot be recovered unless intentional and reprehensible conduct is proven by clear and convincing evidence; provided, however, that in no event shall the amount recoverable as punitive damages exceed one million dollars.

(d) All causes of action alleging injury to person or property arise as of the date of injury and must be commenced within two years of the date of such injury, or within two years of the date when such person discovers, or with the exercise of reasonable diligence should have discovered, such injury, whichever last occurs; provided, that in no event shall any such action be commenced more than ten years after the date of injury.

(e) The periods of limitation set forth in subsection (d) shall be tolled as to any owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline for any period during which it is demonstrated by clear and convincing evidence that any such owner, operator or generator intentionally and knowingly concealed or intentionally and knowingly misrepresented material facts related to the mechanical integrity of the carbon dioxide sequestration facility, the chemical composition of any injected carbon dioxide, or the injury.

(f) If the trier of fact renders a verdict for the plaintiff, the court shall enter judgment of several, but not joint, liability against each defendant in accordance with the percentage of fault attributed to the defendant by the trier of fact.

(g) Notwithstanding any other provision of this code, in all civil liability actions against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility of pipeline, and in all public liability actions against the state, regardless of the theory of liability under which they are commenced, the total amount of compensatory damages awarded to a plaintiff in such action shall be reduced by any collateral source payments made or to be made to the plaintiff, except insurance for which the plaintiff, spouse of the plaintiff or parent of the plaintiff has paid the entire premium, insurance that is subject to a right of subrogation, workers' compensation benefits that are subject to a right of subrogation, or insurance that has any other obligation of repayment. The reduction in compensatory damages shall be determined by the court after the verdict and before entry of judgment, and reduction may be made only if the collateral source payments are compensation for the same damages recovered by the verdict. No evidence of collateral source payments may be admitted during trial. After considering the evidence related to collateral source submitted by any party, the court shall make a determination as to the amount by which a plaintiff's compensatory damages will be reduced by any such collateral source payments.

(h) Notwithstanding the case of Bower v. Westinghouse, 552 S.E.2d 424 (W. Va. 1999), in any civil liability action against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, and in any public liability action against the state, a plaintiff may not recover for future medical monitoring, testing, examination, treatment, services, surveillance, or procedures of any kind, including the costs and expenses associated therewith, unless such future medical monitoring, testing, examination, treatment, services, surveillance or procedures are directly related to a present manifestation of physical injury or disease which was caused by or directly related to the tortious or wrongful act of the carbon dioxide sequestration facility owner or operator, carbon dioxide sequestration pipeline operator, carbon dioxide sequestration generator, or the state and which was found to have caused the present physical impairment.

(i) Notwithstanding any other provision of law, absent privities of contract, no plaintiff who files a civil liability action against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility of pipeline, or who files a public liability action against the state, may file an independent cause of action against any insurer of the owner or operator of a sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, or the state, alleging the insurer has violated the provisions of section three, article eleven, chapter thirty-three of this code or subdivision nine, section four, article eleven, chapter thirty-three of this code.

(j) No owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility of pipeline, nor the state, may file a cause of action against their own insurer alleging the insurer has violated the provisions of section three, article eleven chapter thirty-three of this code, or subdivision nine, section four, article, eleven, chapter thirty-three of this code, until there has been a verdict in the underlying action or the case has otherwise been dismissed, resolved or disposed.

§22-11A-13. Carbon Dioxide Management Authority.

(a) There is hereby established an independent agency of the state of West Virginia to be known as the Carbon Dioxide Management Authority. The authority shall consist of three members appointed by the Governor by and with the advice and consent of the Senate for terms of three years. No more than two of the members may at any one time belong to the same political party. One member shall be a person with significant experience in environmental protection. All members of the authority shall be citizens of the state of West Virginia. A member appointed to fill an unexpired term shall serve only for the remainder of that term. Members of the authority shall be reimbursed for reasonable expenses incurred in the discharge of official duties. All expenses incurred by the authority shall be paid in a manner consistent with guidelines of the Travel Management Office of the West Virginia Department of Administration.

(b) The authority shall provide the following functions—

(1) prescribe the form of cost reimbursement agreements, offer such agreements to the secretary with stewardship responsibility, and execute such agreements on behalf of the State of West Virginia,

(2) prescribe compensation schedules and remediation standards,

(3) determine the extent to which public liability claims filed with the authority are payable under applicable compensation schedules,

(4) determine whether remediation actions are required at a closed sequestration facility under the authority's remediation standards,

(5) make payments under cost reimbursement agreements (including payments for remediation costs), and

(6) exercise such other authorities as may be necessary or appropriate to carry out its functions under the preceding subdivisions of this subsection or other provisions of this article, including employment of personnel and entering into contracts.

(c) The authority shall offer the secretary, upon issuance of a certificate of completion, stewardship responsibility for a closed sequestration facility, a contract under which the authority provides reimbursement for costs of monitoring, administration, and remediation of such facility. The authority shall prescribe rules for reimbursement of all reasonable costs of operation, administration, and remediation incurred by the secretary with stewardship responsibility for closed sequestration facilities.

(d) The authority shall prescribe standards for determining whether and to what extent remediation will be required at a closed sequestration facility in order to protect health, safety, or the environment, and the payments for such remediation shall be made from the Carbon Dioxide Sequestration Facility Trust Fund in accordance with the contracts under section sixteen of this article.

(e) The authority shall be responsible for the payments authorized by this article until such time as the federal government assumes responsibility for the long-term monitoring and management of carbon dioxide sequestration facilities.

(f) The authority shall procure insurance coverage for each sequestration facility owned by the state, if and to the extent such a policy is available, that insures against losses stemming from a public liability action arising from the closed sequestration facility. The insurance coverage shall be in an amount determined by regulation. The authority shall pay any insurance premiums and deductibles of the insurance policies procured under this section from the Carbon Dioxide Sequestration Facility Post-Closure Trust Fund.

(g) The authority or the secretary upon authorization of the authority may by rule or order prescribe requirements for monitoring closed sequestration facilities and for making such inspections and reports as may be necessary or appropriate to carry out this article. The authority may on its own, or authorize the secretary, to enter onto the premises or property of any closed sequestration facility to carry out the requirements of this article.

(h) The authority is authorized to enter into agreements and contracts and to expend money in the post-closure trust fund for the following purposes:

(1) to monitor closed sequestration facilities;

(2) to remediate and repair mechanical problems at the closed sequestration facility;

(3) to plug and abandon remaining wells under the jurisdiction of the department of environmental protection except for those wells to be used as observation wells;

(4) to pay premiums and deductibles under any insurance policy purchased in accordance with this article; and

(5) to pay the portion of any public liability claim as authorized by this article; provided that no portion of the money in the trust fund shall be used to defray the costs of administering this article.

(6) to compensate, through a cooperative agreement with another state regulatory agency in this or another state, the cooperating agency for expenses the cooperating agency incurs in carrying out the regulatory responsibilities that agency may have over a closed sequestration facility regulated pursuant to this article during the post-closure phase of such facility.

(i) The authority, after consultation with the secretary, shall by rule prescribe compensation schedules for determining the nature and amount of compensation that will be paid from the Carbon Dioxide Sequestration Post-Closure Trust Fund for public liability claims.

(j) The authority is hereby authorized to promulgate rules or authorize the secretary to promulgate rules related to the setting and collection of post-closure fees.

(l) Rules of general applicability prescribed under this article by the secretary or the authority shall be reviewed in the same manner provided in section nine, article one, chapter twenty-two-b of this code.

§22-11A-15. Stewardship responsibility for closed sequestration facilities.

(a) The secretary shall, after notice and opportunity for comment, assume stewardship responsibility for closed sequestration facilities in West Virginia in accordance with the provisions of this article until such time as the federal government assumes responsibility for the long-term stewardship of carbon dioxide sequestration facilities.

(b) Upon issuance of the certificate of completion for a carbon dioxide sequestration facility, the secretary shall be responsible for continued monitoring of that facility, and for any remediation that is required by the authority or that the secretary determines is necessary and is authorized by the authority. The secretary's costs of monitoring, program administration, and remediation shall be reimbursed by the authority from the carbon dioxide sequestration facility post-closure trust fund pursuant to a reimbursement contract under this article.

§22-11A-16. Transfer of liability during the post closure phase.

(a) Unless the secretary allows an earlier filing, for good cause shown, the owner or operator of a carbon dioxide sequestration facility may apply for a certificate of completion of injection operations no earlier than ten years after the cessation of operation related to the injection of carbon dioxide into such facility. The secretary shall issue a certificate of completion of injection operations upon a showing by the project operator that such facility has been closed in accordance with an approved closure plan, and the reservoir is reasonably expected to retain mechanical integrity and the carbon dioxide is reasonably expected to remain emplaced. Upon the issuance of the certificate of completion, ownership of such facility shall transfer to the West Virginia Carbon Dioxide Management Authority.

(b) Upon issuance of the certificate of completion for a carbon dioxide sequestration facility:

(1) all public liability claims related to that facility and arising or accruing on and after the date on which the certificate of completion was issued shall be filed against the authority, and

(2) the project operator of such facility, the owner of such facility, any carbon dioxide transmission pipeline that transported carbon dioxide to such facility, the owner of the carbon dioxide sequestered in such facility, the owner of the reservoir in which the carbon dioxide is being sequestered and the generator of the carbon dioxide being handled by either such facility or pipeline shall not be subject to any civil liability claim after the issuance of the certificate of completion, unless it is demonstrated by clear and convincing evidence that any such operator, owner, or generator intentionally and knowingly concealed or intentionally and knowingly misrepresented material facts related to the mechanical integrity of the carbon dioxide sequestration facility or the chemical composition of any injected carbon dioxide.

(c) The secretary has stewardship responsibility for a closed carbon dioxide sequestration facility; however, the secretary shall not be subject to any civil liability claim as a result of its assuming stewardship responsibility.

14. Fees

It is anticipated that there will be separate mechanisms for obtaining fees: (1) an application fee; (2) an administrative fee managed in an administrative fund for operational costs, which may also be used to defray the expenses of regulatory agencies other than the WVDEP; and (3) a post closure fee managed in a trust fund for post operational costs.

Application Fee

(b) Upon filing an application, an applicant shall pay a reasonable fee, as established by the secretary in legislative rules, to the department for the costs of reviewing, evaluating and processing the permit, serving notice of an application and holding any hearings. The fee ~~shall be credited to a separate account and~~ shall be used by the department as required to complete the tasks necessary to process, publish and reach a decision on the permit application.

a. Operational Phase Fee

§22-11A-11. Carbon dioxide sequestration facility operational fund.

(a) In lieu of any other fees that may otherwise be charged by the secretary, sequestration operators shall pay an operational fee established by the secretary in a legislative rule. The amount of the fee shall be based on the anticipated expenses that the department will be reasonably expected to incur in regulation of a carbon dioxide sequestration facility pursuant to this article during the construction, operational, and pre-closure phases of such facilities. The total amount of the fee so assessed may not exceed the lesser of one hundred and fifty thousand dollars per year or one cent per metric tonne of carbon dioxide injected for sequestration. The operational fee may also include an additional amount based upon the anticipated expenses that regulatory agencies other than the department will be reasonably expected to incur in regulation of a carbon dioxide sequestration facility permitted pursuant to this article. The operational fee shall be maintained in a fund to be called the carbon dioxide sequestration facility operational fund. The fund must be maintained as a special fund and all money or interest in the fund shall be used solely for defraying the cost of expenses that regulatory agencies actually incurred in regulation of carbon dioxide sequestration facilities pursuant to this article during the construction, operational, and pre-closure phases of such facilities.

(b) All unexpended permit fees and the net proceeds of all fines, penalties and bond forfeitures collected under this article shall also be paid into the carbon dioxide sequestration operational fund. Interest earned by the fund must be deposited in the fund.

(c) The secretary, through a cooperative agreement with another state regulatory agency, in this or another state, may use the fund to compensate the cooperating agency for expenses the cooperating agency incurs in carrying out regulatory responsibilities that agency may have over a carbon dioxide sequestration facility regulated pursuant to this article during the construction, operational, and pre-closure phases of such facility.

(d) No less frequently than every five years, the secretary shall review, and revise as appropriate, the operational fee authorized by this section to assure that the fee meets the requirements of this section.

(e) Any funds held by the carbon dioxide sequestration facility operational fund in excess of the amounts needed to accomplish the purposes of this section shall be deposited in the carbon dioxide sequestration facility post-closure trust fund established pursuant to section fourteen of this article. In no event shall such excess funds be transferred to the state's general revenue fund or elsewhere.

(f) The secretary is hereby authorized to promulgate rules and regulations related to the setting and collection of fees pursuant to this section.

b. Post Closure Fees

A trust fund should be established during the operational phase of the project to provide funds to maintain the facility in the post closure phase, to purchase insurance, and if necessary to respond to claims. Provision should be made for the handling of subsequent sequestration facilities.

§22-11A-14. Establishment of Post-closure Trust Fund, Post-closure fee.

(a) There is hereby established the Carbon Dioxide Sequestration Facility Post-closure Trust Fund to be administered by the Carbon Dioxide Management Authority.

(b) Sequestration operators shall pay a post-closure fee on each metric tonne of carbon dioxide injected for sequestration, which shall be imposed periodically during the operational phase of the project. The fee shall be in the amount established by the authority in a legislative rule. The trust fund shall be utilized for the administration of closed sequestration facilities and may not exceed seven cents per metric tonne of carbon dioxide injected for sequestration. The post-closure fee shall be maintained in the trust fund established under subsection (a) of this section which shall be maintained as a special fund and all money or interest in the fund shall be used for the purpose set forth in this article.

(c) Interest earned by the fund must be deposited in the fund.

(d) Once any single sequestration operator has contributed fifty million dollars to the trust fund, the fee assessments to that sequestration operator under this section shall cease. The authority shall on its own accord or authorize the secretary to promulgate by legislative rule the nature and extent to which such fee may be reduced to account for the existence of multiple facilities and to assure that the trust fund contains only enough as can be justified on the basis of an actuarially determined assessment of risk.

(e) No less frequently than every five years, the authority shall review, and revise as appropriate, the per metric tonne post-closure fee authorized by this section to assure that the fee meets the requirements of this section.

15. Interstate Projects

Due to the fact that the geologic basins containing formations suitable for geologic sequestration cross state boundaries creating the likelihood that plumes from the injection formation could cross into another state, it is necessary to authorize the secretary to enter into cooperative agreements with other governments or government entities.

Cooperative agreements.

(a) The secretary is authorized to enter into cooperative agreements with other governments or government entities for the purpose of regulating carbon dioxide ~~storage projects~~ sequestration facilities or carbon dioxide transmission pipelines that extend beyond state regulatory authority under this article.

(b) If a cooperative agreement is entered into by the secretary with another state or government entity and the state or government entity has similar laws or regulations regarding permit requirements for a carbon dioxide sequestration facility or a carbon dioxide transmission pipeline, exercising the right of eminent domain, authorization for the use of pore space, post closure liability transfer, and the funding of administrative and liability issues, then persons holding a permit authorizing a carbon dioxide sequestration facility issued by the other state or government entity are authorized to use pore space in this state, unitize property, and to exercise the power of eminent domain to acquire surface and subsurface rights and property interests as provided in this article in accordance with the terms of such cooperative agreement.

16. The continued role of the Working Group

Determining the role the Working Group will play in the development of rules and whether the development of those rules would come before or after July 1, 2011. This should involve understanding the relationship that should exist with the existing environmental protection advisory council.

§ 22-11A-17. Carbon dioxide sequestration working group.

(a) The secretary shall establish the carbon dioxide sequestration working group.

(b) The secretary, in cooperation with the state geologist, shall appoint at least fifteen persons to serve on the working group.

(c) In selecting persons to serve on the working group, the secretary and the state geologist shall appoint at least three persons who are experts in carbon dioxide sequestration or related technologies, at least one person who is an expert in environmental science, at least one person who is an expert in geology, at least one person who is an attorney with an expertise in environmental law, at least one person who is an expert in engineering, at least one person who is an expert in the regulation of public utilities in West Virginia, one person who is a representative of a citizen's group advocating environmental protection, a representative of a coal power electric generating utility advocating carbon dioxide sequestration development, at least one person who is an engineer with an expertise in the underground storage of natural gas, the chairman of the National Council of Coal Lessors or his/her designee, a representative of the West Virginia Coal Association, a representative of the West Virginia Land and Mineral Owners Association, and at least one representative advocating the interests of surface owners of real property.

(d) The working group shall study issues pertaining to carbon dioxide sequestration including, but not limited to, scientific, technical, legal and regulatory issues, and issues regarding ownership and other rights and interests in subsurface space that can be used as storage space for carbon dioxide and other associated constituents, or other substances, commonly referred to as "pore space," and shall report to the secretary and the Legislature its recommendations with respect to the development, regulation and control of carbon dioxide sequestration and related technologies.

(e) In addition, the working group shall develop a long-term strategy for carbon dioxide sequestration in West Virginia.

(f) The working group may conduct or initiate studies, scientific or other investigations, research, experiments and demonstrations pertaining to carbon dioxide sequestration, and to this end, the working group may cooperate with state institutions of higher education or any public or private agency. The secretary may receive on behalf of the state for deposit in the State Treasury any moneys which such institutions or state agencies may be authorized to transfer to the secretary, and all gifts, donations or contributions which such private agencies or others may provide, to defray the expenses of the working group. Any amounts so received shall be expended by the secretary solely for the purposes set forth in subsection (d) of this section.

~~(g) The working group shall issue a preliminary report to the secretary and the Legislature by July 1, 2010, containing any preliminary recommendations or findings of the working group.~~

~~(h) The working group shall issue a final report to the Legislature by July 1, 2011, which report shall, at a minimum:~~

~~(1) Recommend appropriate methods to encourage the development of carbon dioxide sequestration technologies;~~

~~(2) Assess the economic and environmental feasibility of large, long-term carbon dioxide sequestration operations;~~

~~(3) Recommend any legislation the working group may determine to be necessary or desirable to clarify issues regarding the ownership and other rights and interest in pore space;~~

~~(4) Recommend methods of facilitating the widespread use of carbon dioxide sequestration technology throughout West Virginia;~~

~~(5) Identify geologic sequestration monitoring sites to assess the short-term and long-term impact of carbon dioxide sequestration;~~

~~(6) Assess the feasibility of carbon dioxide sequestration in West Virginia and the characteristics of areas within the state where carbon dioxide could be sequestered;~~

~~(7) Assess the costs, benefits, risks and rewards of large-scale carbon dioxide sequestration projects in West Virginia;~~

~~(8) Assess the potential carbon dioxide sequestration capacity in this state;~~

~~(9) Identify areas of research needed to better understand and quantify the processes of carbon dioxide sequestration; and~~

~~(10) Outline the working group's long-term strategy for the regulation of carbon dioxide sequestration in West Virginia.~~

~~(i) The working group, along with the state geologist, shall assist the secretary in developing and promulgating legislative rules under this article.~~

(g) In addition to its other responsibilities under this article, the working group shall for a period of five years from the effective date of this section:

(1) Consult with and advise the secretary and authority on program and policy development, problem solving, rulemaking, and other appropriate subjects; and

(2) Identify and define problems associated with the implementation of the policy set forth in section two of this article;

18. Ownership and Value of Stored CO_2

The owners of a reservoir being used for the sequestration of carbon dioxide need to receive assurances that they will be allowed to participate in any economic value that may be associated with the possible removal for profit of the carbon dioxide once it is geologically sequestered. There may be a limited opportunity to extract sequestered CO_2 as it stabilizes in the porespace and becomes more difficult to extract as time passes. Draft provisions governing title to and use of CO_2 managed in a sequestration operation follow.

§22-11A-~~8~~10. Oil, natural gas and coalbed methane activities at carbon dioxide sequestration ~~sites~~ facility; extraction of sequestered carbon dioxide.

(a) Nothing in this article shall be deemed to affect the otherwise lawful right of a ~~mineral owner~~ person to drill or bore through or to otherwise exercise rights near a carbon dioxide sequestration ~~site~~ facility, if done in accordance with the rules promulgated under this article for protecting the carbon dioxide sequestration ~~site~~ facility against the escape of carbon dioxide.

(b) Nothing in this article is intended to impede or impair the ability of an oil, natural gas or coalbed methane operator to inject carbon dioxide through an approved enhanced oil, natural gas or coalbed methane recovery project and to establish, verify, register and sell emission reduction credits associated with the project.

(c) The ~~Office of Oil and Gas~~ secretary shall have jurisdiction over any subsequent extraction of sequestered carbon dioxide that is intended for commercial or industrial purposes.

(d) Except as herein specifically provided, nothing in this article shall alter or amend existing state law regarding correlative property rights or the primacy of the oil, natural gas, coal, coalbed methane or other mineral estate.

(e) Title to the carbon dioxide injected into and stored in a carbon dioxide sequestration facility is vested in the owner or operator of such facility, and such owner or operator retains title throughout the operational life of such facility, and until the secretary issues a certificate of completion.

(f) Once the secretary has issued a certificate of completion, title to the carbon dioxide sequestered in a carbon dioxide sequestration facility transfers to the owner of the right to use the reservoir unless that owner cannot be determined in which case title to such carbon dioxide transfers to the owner of the surface estate.

(g) Any extraction for profit of carbon dioxide sequestered in a carbon dioxide sequestration facility shall be undertaken only with the agreement of the owner of the right to use the reservoir or the owner of the surface estate in the event the owner of the right to use the reservoir cannot be determined. Any extraction of carbon dioxide sequestered in a carbon dioxide sequestration facility for the purpose of remediation or for the protection of human health or the environment may be undertaken without the agreement of such owner.

(h) Except as herein specifically provided, nothing in this article shall alter, amend, diminish or invalidate rights to use a reservoir that was acquired by contract or lease prior to the effective date of this article, including, without limitation, rights acquired for the underground storage of natural gas, or in connection with the extraction or production of oil, natural gas, coal, coalbed methane or other minerals, including, without limitation, rights for the secondary recovery of coal, oil, natural gas, coalbed methane or other minerals by injection of carbon dioxide or water or by other means.

19. Penalties, Severability, and Confidentiality

It became apparent to the Legal Subcommittee that it was necessary to add such provisions for penalties, severability, and confidentiality. The penalities section was modeled after the Groundwater Protection Act. The severability section is standard severability language. The confidentiality section was modeled after the recent Water Resources Protection Act to include post-911 protections of information.

§22-11A-20. Civil, administrative, and criminal penalties; compliance orders.

(a) Any person who violates any provision of this article, or any permit or agency approval, rule or order issued to implement this article, is subject to civil penalties in accordance with the provisions of section twenty-two, article eleven of this chapter: Provided, That such penalties are in lieu of civil penalties which may be imposed under other provisions of this code for the same violation.

(b) Any person who willfully or negligently violates any provision of this article, or any provision of a permit or agency approval, rule or order issued to implement this article, is subject to criminal penalties in accordance with the provisions of section twenty-four, article eleven of this chapter: Provided, That such penalties are in lieu of other criminal penalties which may be imposed under other provisions of this code for the same violation.

(c) Any person who violates any provision of this article, or any permit or rule or order issued to implement this article, is subject to a civil administrative penalty to be levied by the secretary or the authority, as appropriate, of not more than five thousand dollars a day per violation, the total penalty for such violation shall not exceed twenty thousand dollars. No combination of assessments against any violator under this section may exceed twenty-five thousand dollars per day. In assessing any such penalty, the secretary or authority, as appropriate, shall take into account the seriousness of the violation and any good faith efforts to comply with applicable requirements as well as any other appropriate factors as may be established by such official by legislative rules promulgated pursuant to this article and the provisions of chapter twenty-nine-a of this code. No assessment may be levied pursuant to this subsection until after the alleged violator has been notified by such official by certified mail or personal service. The notice shall include a reference to the section of the statute, rule, order or statement of permit conditions that was allegedly violated, a concise statement of the facts alleged to constitute the violation, a statement of the amount of the administrative penalty to be imposed and a statement of the alleged violator's right to an informal hearing. The alleged violator shall have twenty calendar days from receipt of the notice within which to deliver to such official a written request for an informal hearing. If no hearing is requested, the notice becomes a final order after the expiration of the twenty-day period. If a hearing is requested, the secretary or authority, as appropriate, shall inform the alleged violator of the time and place of the hearing. The secretary or authority, as appropriate, may appoint an assessment officer to conduct the informal hearing who shall make a written recommendation to such official concerning the assessment of a civil administrative penalty. Within thirty days following the informal hearing, the secretary or authority, as appropriate, shall issue and furnish to the violator a written decision, and the reasons therefore, concerning the assessment of a civil administrative penalty. Within thirty days after notification of the secretary's or authority's, as appropriate, decision, the alleged violator may request a formal hearing before the environmental quality board in accordance with the provisions of this article. Any administrative civil penalty assessed pursuant to this section is in lieu of any other civil penalty which may be assessed under any provision of this code for the same violation. All administrative penalties shall be levied in accordance with legislative rules promulgated by such official in accordance with the provisions of chapter twenty-nine-a of this code.

(d) The net proceeds of all civil penalties collected pursuant to this section and all assessments of any civil administrative penalties collected pursuant to this section shall be deposited into the carbon dioxide sequestration facility post-closure trust fund established pursuant to this article.

(e) The secretary or authority, as appropriate, may seek an injunction, or may institute a civil action against any person in violation of any provision of this article or any permit, agency approval, rule or order issued to implement this article. In seeking an injunction, it is not necessary for the secretary or authority, as appropriate, to post bond nor to allege or prove at any point in the proceeding that irreparable damage will occur if the injunction is not issued or that the remedy at law is inadequate. An application for injunctive relief or a civil penalty action under this section may be filed and relief granted notwithstanding the fact that all administrative remedies provided for in this article have not been exhausted or invoked against the person or persons against whom such relief is sought.

(f) If the secretary or authority, as appropriate, upon inspection, investigation or through other means observes, discovers or learns of a violation of the provisions of this article, or any permit, order or rules issued to implement the provisions of this article, he or she may issue an order stating with reasonable specificity the nature of the violation and requiring compliance immediately or within a specified time. An order under this section includes, but is not limited to, any or all of the following: Orders implementing this article which (1) suspend, revoke or modify permits; (2) require a person to take remedial action; or (3) are cease and desist orders.

(g) Any person issued a cease and desist order under subsection (f) of this section may file a notice of request for reconsideration with the secretary or authority, as appropriate, not more than seven days from the issuance of such order and shall have a hearing before such official to contest the terms and conditions of such order within ten days after filing such notice of a request for reconsideration. The filing of a notice of request for reconsideration does not stay or suspend the execution or enforcement of such cease and desist order.

§22-11A-21. Confidentiality.

(a) Information required to be submitted by a project operator or owner pursuant to this article that may be a trade secret, contain protected information relating to homeland security or be subject to another exemption provided by the state freedom of information act may be deemed confidential. Each such document shall be identified by that person as confidential information. The person claiming confidentiality shall provide written justification to the secretary at the time the information is submitted stating the reasons for confidentiality and why the information should not be released or made public. The secretary has the discretion to approve or deny requests for confidentiality as prescribed by this section.

(b) In addition to records or documents that may be considered confidential under article one, chapter twenty-nine-b of this code, confidential information means records, reports or information, or a particular portion thereof, that if made public would:

(1) Divulge production or sales figures or methods, processes or production unique to the submitting person;

(2) Otherwise tend to adversely affect the competitive position of a project operator or owner by revealing trade secrets, including intellectual property rights; or

(3) Present a threat to the safety and security of any water supply, including information concerning water supply vulnerability assessments.

(c) Information designated as confidential and the written justification shall be maintained in a file separate from the general records related to the person.

(d) Information designated as confidential may be released when the information is contained in a report in which the identity of the person has been removed and the confidential information is aggregated by hydrologic unit or region.

(e) Information designated as confidential may be released to governmental entities, their employees and agents when compiling and analyzing survey and registration information and as may be necessary to develop the legislative report required by this section or to develop water resources plans. Any governmental entity or person receiving information designated confidential shall protect the information as confidential.

(f) Upon receipt of a request for information that has been designated confidential and prior to making a determination to grant or deny the request, the secretary shall notify the person claiming confidentiality of the request and may allow the project operator or owner an opportunity to respond to the request in writing within five days.

(g) All requests to inspect or copy documents shall state with reasonable specificity the documents or type of documents sought to be inspected or copied. Within ten business days of the receipt of a request, the secretary shall: (1) Advise the project operator or owner making the request in writing of the time and place where the project operator or owner may inspect and copy the documents which, if the request addresses information claimed as confidential, may not be sooner than twenty days following the date of the determination to disclose, unless an earlier disclosure date is agreed to by the project operator or owner claiming confidentiality; or (2) deny the request, stating in writing the reasons for denial. If the request addresses information claimed as confidential, then notice of the action taken pursuant to this subsection shall also be provided to the project operator or owner asserting the claim of confidentiality.

(h) Any project operator or owner adversely affected by a determination regarding confidential information under this article may appeal the determination to the appropriate circuit court pursuant to the provisions of article five, chapter twenty-nine-a of this code. The filing of a timely notice of appeal shall stay any determination to disclose confidential information pending a final decision on appeal. The scope of review is limited to the question of whether the portion of the records, reports, data or other information sought to be deemed confidential, inspected or copied is entitled to be treated as confidential under this section. The secretary shall afford evidentiary protection in appeals as necessary to protect the confidentiality of the information at issue, including the use of in camera proceedings and the sealing of records when appropriate.

§22-11A-22.Severability.

If any provision of this article or its application to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of this article which can be given effect without the invalid provision or application, and to this end the provisions of this article are severable.

V. Proposed Discussion Draft of West Virginia Carbon Dioxide Sequestration Act.

In an effort to bring together its various recommendations, the WVCCS Working Group has prepared and attaches a draft bill. It is the hope and expectation of the Working Group that this draft bill will be considered by the Governor, members of the Legislature and the public as a starting point in the discussion about actions which need to be undertaken to facilitate CCS development in West Virginia.

VI. SUMMARY

During the 2009 Regular Session, the West Virginia Legislature passed H.B. 2860 which was added to the West Virginia Code as Carbon Dioxide Sequestration, Article 11A of Chapter 22. The Legislature listed among its findings that "[i]t is in the public interest to advance the implementation of carbon dioxide capture and sequestration technologies into the state's energy portfolio." Recognizing that there are administrative, technical and legal questions involved in developing this new technology, the Code authorized the West Virginia Department of Environmental Protection (WVDEP) Secretary to establish a Carbon Dioxide Sequestration Working Group ("Working Group"). The Working Group is charged with studying all issues related to the sequestration of carbon dioxide and to submit a preliminary report to the Legislature on July 1, 2010, followed up by a final report due on July 1, 2011. The final report must address, at a minimum, the following:

- A recommendation of the appropriate methods to encourage the development of carbon dioxide sequestration technologies;
- An assessment of the economic and environmental feasibility of large, long-term carbon dioxide sequestration options;
- A recommendation of any legislation the working group may determine to be necessary or desirable to clarify issues regarding the ownership and other rights and interest in pore space;
- A recommendation of the methods of facilitating the widespread use of carbon dioxide sequestration technology throughout West Virginia;
- Identification of geologic sequestration monitoring sites to assess the short-term and long-term impact of carbon dioxide sequestration;
- An assessment of the feasibility of carbon dioxide sequestration in West Virginia and the characteristics of areas within the state where carbon dioxide can be sequestered;
- An assessment of the costs, benefits, risks and rewards of large-scale carbon dioxide sequestration projects in West Virginia;
- An assessment of the potential carbon dioxide sequestration capacity in this state;
- Identification of areas of research needed to better understand and quantify the processes of carbon dioxide sequestration; and
- An outline of the working group's long-term strategy for the regulation of carbon dioxide sequestration in West Virginia.

(W. Va. Code § 22-11A-6(h)(1)-(10)).

This Final Report was prepared and submitted in compliance with the Carbon Dioxide Sequestration Act. It describes the efforts of the Working Group and its findings and recommendations to the Legislature.

VII. MINORITY OPINIONS

VII.A. Minority Report on Risk Assessments for Long Term Geologic Storage of Carbon Dioxide.

By John Leeson on June 28, 2011; Dominion Transmission.

There have been some risk assessments for long term geologic storage of carbon dioxide. My understanding is that some of the risk assessments have been done or assisted by mathematical modeling or simulations.

I do not have confidence in calculated probabilities of carbon dioxide loss from geologic storage.

In my opinion, there is insufficient current information and carbon dioxide storage history to accurately determine risk probabilities of carbon dioxide loss from geologic storage, particularly from aquifers. Most of the potential carbon dioxide storage capacity in West Virginia is in saline aquifers.

It seems to me that the risk of carbon dioxide loss will likely be different from different geologic formations used for storage such as depleted oil and gas fields, coal seams and aquifers. One general calculated risk probability value is not likely to adequately describe the risks of storage in various types of formations.

VII.B. Minority Report on Acquisition of Right to Use the Pore Space. June 30, 2010

Prepared by David McMahon, J.D.; Surface owners representative.1624 Kenwood Road, Charleston, WV 25301. Voice/Voicemail 304-415-4288 E-mail: wvdavid@wvdavid.net

This minority report on the work of the Legal Subcommittee will not be lengthy because this is an interim report, and because of constraints on funding for the participation of pubic interest members. It will only be on one of the subjects that the Legal Subcommittee addressed without waiving the right to comment on other aspects of the final report. A comment in an earlier draft of this Minority Report on the issue of ultimate “liability transfer” took the position that the sequestering entity should always retain some liability, like a deductible, for public policy reasons. Since the Legal Subcommittee has not discussed that issue, the comment was removed.

Acquisition of right to use the pore space

The Carbon Dioxide Sequestration Working Group was initiated by Legislation. The introduced version of that legislation included a presumption that the owner of the surface of any tract of land also owned the pore space – meaning that it would need to be purchased or taken the same as any other interest in land before it could be used for carbon sequestration. How far we have come.

That initial universal presumption did go too far, and it was not included in the final legislation. There are circumstances where the fee owner of a tract of land deeds the surface to another owner, and the clear contemplation of the parties is that the purchaser is only getting the surface (and even that surface is subject to the mineral owners rights to use the surface for obtaining the minerals using methods in the contemplation of the partes at the time of the severance deed). That surface owner does not own, and should not be presumed to have, any rights to the pore space in that limited situation.

However, in many, probably most cases, the deeding away of oil and gas, or coal, or minerals, by someone who kept what was not deeded away, did not contemplate the deeding of the right to use pore space. Indeed that has been the working premise of the long established conventional natural gas storage industry in West Virginia for many, many years. So lots of surface owners own pore space even if they do not also own the minerals.

And owners who own the minerals but not the surface are not so concerned about the effects on the surface or the potential harm to groundwater etc. But those mineral owners who do also own the pore space believe that they have something valuable – increasingly valuable it turns out.

The Legal Subcommittee recognized early on that the subcommittee could provide a number of different options for a legal regime and process for establishing the right to sequester carbon dioxide in the pore space of land owned by others. There are opponents of carbon sequestration who may well sue to stop it. The options will be on a continuum that includes a consideration of the possible law suit to stop it. On one end is a regime and process that will guarantee that there will be no successful legal challenge on basis of taking or trespass, but which require much greater time and effort and expense to accomplish. On the other end of the continuum are regimes and processes which will be quick and cheap, but unlikely to stand up to constitutional and other challenges in the courts.

A distilling of the subcommittee's progress would be that its thinking started almost on one end of the spectrum, but ended up at the other end of the spectrum. The subcommittee learned more and more about how difficult it would be to identify the owners of the pore space and contact them to purchase the right to use it or, in the event they were unwilling to sell it for the price offered, condemn it. Also, the political difficulties of condemnation legislation entered into the analysis. So the subcommittee searched harder and harder for some alternative. Without finding any legal authority that this report believes is solid, it abandoned notice and negotiated purchase/condemnation of individual tracts. While this minority report can only compliment the thoroughness and openness of the effort, the result in the interim report is not fair to the owners of pore space, whoever they may be, or to owners of other interests in the land whether they be surface or gas. And in addition it will not likely stand up to constitutional scrutiny. And the result is certainly not certain enough of its constitutionality to prevent carbon sequestration from being held up by long litigation over its constitutionality. In addition, its apparent unfairness to land interest owners will probably not have a greater likelihood of success in the Legislature than would increasing condemnation rights.

The subcommittee's current recommendation is in essence that,

> "We can pump carbon dioxide under your land at such high pressures that it will not turn to gas. We can do it without your permission unless you get some general notice sent to the public and point out during a permit

process that the project will 'impair a current or reasonably foreseeable use of the geologic strata [not strata above and below that strata that may be impaired, but the strata used for sequestration] for a qualifying purpose'. And we do not have to pay you for doing this under your land unless you have a current or reasonably foreseeable economic use utilizing then-current production techniques or technologies that are feasible for use in this region. The reason we can do this is that we need to do this really badly and it is too hard to do it any other way, so we think the courts will say it is not a trespass or a taking. And if we do need to take it from you because you have a current economic use for it, then we will compensate you on what the pore space was worth to you the seller and not to us the buyer."

The report analogizes the sequestering of carbon dioxide to the regime of law for disposal of *treated* municipal waste water in Florida or a court case for salt water disposal in Ohio. This minority report does not think that our courts will find those processes to be analogous to carbon sequestration, or that, our courts would be persuaded by the legal reasoning of those regimes and cases in other states even if the circumstances were analogous.

When we started we were cynical that using someone's property without finding and compensating them was not going to be acceptable. Since we figured out how hard that would be, we have convinced ourselves that it is possible to do it differently. We have figured this out only in the face of the difficulty of doing it otherwise. We have not come to this conclusion based on based on newly discovered law or facts.

What the committee should do is a further investigation of processes and statutory evidentiary, valuation and other presumptions in order to more economically find the owners and compensate them.

One particular problem is that using one formation for carbon sequestration will make it more difficult to drill to gas (or other) resources in lower formations. This could cause producers to want to drill instead on tracts where there is no carbon sequestration, and so lower the value of the tracts underlain by carbon sequestration. A possible avenue of investigation to address that is to keep escrows to compensate owners for the extra cost of drilling through formations used for carbon sequestration in the event the owner ever finds it necessary or convenient to drill through the formation used for carbon sequestration to deeper gas or other resources.

Below is a list of the interests who would oppose the use of their land for carbon sequestration and their rationale. It is supplied both to show some of the legal reasoning to be avoided and show the motivation to oppose carbon sequestration.

1. It's mine and I don't want you doing with it just because its mine and not yours and this is America and you should not be able to take it any more than you should be able to take my guns.
2. It's mine and I do not want it harmed – particularly the surface and groundwater, but all of it really. You say that supercritical carbon dioxide will not get loose and come to the surface, but I do not believe you. You can't prove a negative to my satisfaction – that it will not harm me or my land somehow. Particularly when we have 1) 50,000 active oil and gas wells in the state with un-cemented annular spaces in between the

cementing of the surface/coal casing and the cementing of the production pipe at the bottom of the hole near the production formation, and 2) there are 9000, or maybe more, pre-1929 orphaned oil and gas wells that have not been plugged at all and more than 10,000 post-1929 wells that need plugged that the State does not have the resources to make the industry plug. I do not want that carbon sequestered under me.

3. It's mine and you are taking it and you need to pay me. Fundamental fairness. How come those people in New York don't have to pay me for it just because they need it very badly. You can say you can trespass onto me without paying me or "taking" it because I am suffering no harm. But if it has value to you, how come you are now saying it has no value to me.
4. It's mine and you are ruining/diminishing the speculative value of the formation you are using and the formations below it. Just because I am not using it now, or have no immediate plans to drill through it to possible deeper formations right now, does not mean it does not have value to me. No one thought the Marcellus Shale was worth anything three years ago, but new discoveries and technologies have made it the most valuable gas find ever in West Virginia! Some day they will discover deeper gas or some other valuable substance, but it will cost more to get through the formation where the carbon dioxide is sequestered so they will go do it on someone else's land. Don't tell me that speculative value does not mean anything. If that was true, surface owners could buy their minerals back for what they sold it for.

The draft recommendation saying that those objections are not relevant because "It's not yours," will be an inadequate response to these interest groups, and the courts and the Legislature.

West Virginia
Carbon Dioxide Sequestration Act

Prepared by the
West Virginia Carbon Dioxide Sequestration
Working Group

June 29, 2011

West Virginia
Carbon Dioxide Sequestration Act

June 29, 2011

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West Virginia Carbon Dioxide Sequestration Act
June 29, 2011

Chapter 22 ENVIRONMENTAL RESOURCES

Article 11A. CARBON DIOXIDE SEQUESTRATION

§ 22-11A-1. Short Title.

This article may be known and cited as the "Carbon Dioxide Sequestration Act."

§ 22-11A-~~1~~2. Legislative findings.

(a) The Legislature finds that:

(1) Carbon dioxide is a colorless, odorless gas that can be produced by burning carbon and organic compounds;

(2) Carbon dioxide is emitted into the atmosphere from a number of sources including fossil-fueled power plants, automobiles, certain industrial processes and other naturally occurring sources;

(3) By far, fossil-fueled power plants are the largest source of carbon dioxide emissions. These power plants emit approximately one-third of carbon dioxide emissions worldwide;

(4) On average, the United States generates approximately fifty-one percent of its electricity from coal-burning plants, which are a prominent source of carbon dioxide emissions;

(5) West Virginia's reliance on electricity produced from coal is even more pronounced, as West Virginia generates approximately ninety-eight percent of its electricity from coal burning power plants;

(6) There is increasing pressure, both nationally and worldwide, to produce electrical power with an ever-decreasing amount of carbon dioxide emissions;

(7) West Virginia is a state rich in natural resources, and its economy depends largely upon the demand for energy produced from materials found within the state, not the least of which is coal;

(8) As demand for energy produced from alternative and renewable resources rises, new technologies are needed to burn coal more cleanly and efficiently if West Virginia is to remain competitive as an energy producing state;

(9) Carbon dioxide capture and sequestration is the capture and secure storage of carbon dioxide that would otherwise be emitted to, or remain in, the atmosphere. This technology is currently being used and tested to reduce the carbon footprint of electricity generated by the combustion of coal;

(10) The science of carbon dioxide capture and sequestration is advancing rapidly, but the environmental

effects of large, long-term carbon dioxide sequestration operations are still being studied and evaluated;

(11) Although the state is committed to expanding its portfolio of alternative and renewable energy resources, electricity generated from these resources is insufficient in the near term to meet the rising demand for energy;

(12) It is in the public interest to advance the implementation of carbon dioxide capture and sequestration technologies into the state's energy portfolio;

(13) Inasmuch as the subsurface sequestration of carbon dioxide is necessary to confront the challenges the world faces with climate change and increasing energy demands, it is appropriate for the state to ensure that geologic formations throughout the state can be used for the purpose of carbon dioxide sequestration in accordance with this article;

(14) It is in the public interest to declare as a public use the use of portions of certain deeper geologic formations for the purpose of carbon dioxide sequestration in accordance with a permit issued pursuant to this article, so long as those portions of geologic formations do not have a current or reasonably foreseeable use for a qualifying purpose;

(15) The state should provide for a coordinated statewide program authorizing access to and use of specific portions of

the geologic formations, regulating the injection, storage and withdrawal of carbon dioxide, and fulfilling the state's primary responsibility for assuring compliance with the federal Safe Drinking Water Act, including any amendments thereto;

(1~~3~~6) The transportation by pipeline and sequestration of carbon dioxide by a public utility engaged in the generation of electricity may be integral to the construction, maintenance and operation of electric light, heat and power plants operating in the state; and

(1~~4~~7) Therefore, in order to expand more rapidly the generation of electricity with little or no carbon dioxide emissions, it is critical to encourage the development of carbon dioxide capture and sequestration technologies~~; to examine factors that may be integral to the construction, maintenance and operation of carbon dioxide sequestration facilities; and to study the economic and environmental feasibility of large, long-term carbon dioxide sequestration operations~~.

(b) It is therefore the purpose of this article to~~:~~

~~(1)~~ Establish a legal and regulatory framework for ~~the permitting of~~ carbon dioxide sequestration operations~~;~~.

(~~2) Designate a state agency responsible for establishing standards and rules for the permitting of carbon dioxide~~

~~sequestration operations including, but not limited to, rules pertaining to:~~

~~(A) Environmental surveillance of carbon dioxide sequestration operations;~~

~~(B) The monitoring of geologic migration of carbon dioxide and the detection of carbon dioxide excursions;~~

~~(C) Construction standards for carbon dioxide sequestration operations;~~

~~(D) Bonding or other financial assurances; and~~

~~(E) The closure of carbon dioxide sequestration operations, including post-closure monitoring, verification and maintenance; and to~~

~~(3) With the aid of a carbon dioxide sequestration working group, develop a long-term strategy for the regulation of carbon dioxide sequestration.~~

§ 22-11A-~~2~~3. Definitions.

Unless the context in which used clearly requires a different meaning, as used in this article:

(a) “Authority” means the Carbon Dioxide Management Authority established pursuant to section thirteen of this article. ~~Department" means the Department of Environmental Protection~~;

(b) "Carbon dioxide sequestration" means the injection of carbon dioxide and associated constituents into ~~subsurface~~ reservoirs intended to prevent its release into the atmosphere;

(c) "Carbon dioxide sequestration ~~facilities" means the surface equipment used for transport, storage and injection of carbon dioxide, excluding pipelines used to transport carbon dioxide from one or more capture facilities to the sequestration injection site or sites.~~ facility" means the reservoir, the underground equipment and pipelines internal to the carbon dioxide sequestration operation, including injection and withdrawal wells and appurtenant equipment, monitoring wells and appurtenant equipment, and surface buildings and equipment utilized in the sequestration operation, but excluding pipelines used to transport the carbon dioxide from one or more capture facilities to the sequestration injection site or sites. The carbon dioxide sequestration facility also includes any necessary and reasonable areal buffer and subsurface monitoring zones and monitoring wells designated by the secretary for the purpose of ensuring the safe and efficient operation of the sequestration facility for the sequestration of carbon dioxide and to protect against pollution, invasion, and escape or migration of carbon dioxide. A carbon dioxide sequestration facility shall not include carbon capture equipment located at the generator of the carbon dioxide.

~~(d) "Carbon dioxide sequestration site" means the underground carbon dioxide formations where the carbon dioxide is stored or is intended to be stored;~~

(d) "Carbon dioxide transmission pipeline" means a pipeline, compressors, meters and associated equipment and appurtenances used for the purpose of transporting carbon dioxide in this state for underground storage in this state or another state. A carbon dioxide transmission pipeline shall not include carbon capture equipment located at the generator of the carbon dioxide or pipelines that are part of a carbon dioxide sequestration facility. The commission shall establish by rule the beginning point and ending point of a carbon dioxide transmission pipeline.

(e) "Certificate of completion" means a certification issued by the secretary that the project operator has completed injection operations, well closure, and any required monitoring and remediation at a carbon dioxide sequestration facility, after a determination is made that there is a reasonable basis to believe that carbon dioxide is and will continue to be safely stored at the carbon dioxide sequestration facility and will not present an unreasonable risk to health, safety, or the environment, (including drinking water supplies).

(f) “Civil liability claim” means any claim for civil relief with respect to a carbon dioxide sequestration facility that arises from migration of carbon dioxide from such facility or is otherwise related to the injection of carbon dioxide at such facility, excluding:

(1) any claim arising from breach of an express contract, or

(2) in the case of a project operator, any claim arising from (i) willful violation of applicable rules of the regulatory authority, or (ii) any false statement or misrepresentation in an application for a certificate of completion;

(g) “Closed sequestration facility” means a carbon dioxide sequestration facility for which a certificate of completion has been issued;

(h) “Department" means the department of environmental protection;

~~(c) "Excursion" means the migrating of carbon dioxide at or beyond the boundary of a carbon dioxide sequestration site; and~~

(i) "Geologic formation" means a succession of sedimentary beds that were deposited continuously and under the same general conditions, composed of the same kind of rock or a distinctive combination of rock types, and includes the pore space within the succession of sedimentary beds.

(j) "Permit issued pursuant to this article" means a permit issued by the secretary pursuant to this article for the sequestration of carbon dioxide in reservoirs.

(k) "Project operator" means the entity responsible for the operation of a carbon dioxide sequestration facility.

(l) "Public liability" means tort liability respecting a closed sequestration facility, including, without limitations, liability for

(1) personal injury,

(2) property damage,

(3) trespass, and

(4) nuisance.

Such term does not include liability for punitive damages or non-economic losses.

(m) "Qualifying purpose" means the lawful use of reservoirs for any significant purpose, including but not limited to, the storage of natural gas, or the extraction of oil, natural gas, coal, coalbed methane or other minerals in such quantity and quality as to justify commercial production of that oil, natural gas, coal, coalbed methane or other mineral, but does not include the use of such reservoirs for the purpose of storing or sequestering carbon dioxide.

(n) "Regulatory authority" for a carbon dioxide sequestration facility means the Department of Environmental Protection.

(o) "Remediation" means action to remedy leakage or migration of carbon dioxide, including any damages to underground drinking water supplies, or to mitigate or correct other danger to health, safety, or the environment that occurs by reason of prior injection of carbon dioxide at a closed carbon dioxide sequestration facility.

(p) "Reservoir" means that portion of a geologic formation with natural or artificial pore space and suitable for or capable of being made suitable for the injection and sequestration of carbon dioxide.

(~~f~~q) "Secretary" means the secretary of the Department of Environmental Protection.

(r) "Stewardship responsibility" means responsibility for monitoring and remediation of closed carbon dioxide sequestration facilities as provided in section fifteen of this article.

§22-11A-~~3~~4. Requirement to have a permit; authorization for existing carbon dioxide sequestration facility; permit requirements; experimental wells; interference with other sequestration facility; public notice requirements; jurisdiction; application to enhanced recovery; application of article six; judicial review.

~~Prohibition of carbon dioxide sequestration without a permit; injection of carbon dioxide for the purpose of enhancing the recovery of oil or other minerals not subject to the provisions of this article.~~

~~(a) The provisions of article eleven of this chapter apply to all permits issued pursuant to this article except, where the express provisions of this article conflict with the provisions of article eleven of this chapter, the express provisions of this article control.~~

~~(b) Except as set forth in subsection (c) of this section, no person shall engage in carbon dioxide sequestration in this state unless authorized by a permit issued by the department in accordance with section eight, article eleven of this chapter.~~

(a) The owner or operator of a carbon dioxide sequestration facility shall obtain a permit pursuant to this article from the secretary prior to the construction, operation or modification of such facility.

(~~c~~b) The injection of carbon dioxide for purposes of enhancing the recovery of oil or other minerals pursuant to a project approved by the department or for the production of carbon dioxide in connection with the production of natural gas shall not be subject to the provisions of this article.

(~~d~~c) If an oil ~~natural gas or coalbed methane~~ or other minerals recovery operator converts its operations to carbon dioxide sequestration upon the cessation of oil or other mineral recovery operations, then the carbon dioxide sequestration facility ~~the carbon dioxide sequestration site~~ shall be regulated pursuant to this article ~~and article eleven of this chapter~~. ~~If an operator does not convert its operations to carbon dioxide sequestration upon the cessation of oil or other mineral recovery operations, the wells shall be plugged and abandoned in accordance with article six of this chapter.~~

~~(e) Any entity owning or operating a carbon dioxide sequestration facility which has commenced construction on or before the effective date of this article is hereby authorized to continue operating until such time as the secretary has established operational and procedural requirements applicable to such existing facilities and the entity owning or operating such facility has had a reasonable opportunity to comply with those requirements.~~

(~~b~~d) Any entity owning or operating a carbon dioxide sequestration facility in existence on the effective date of this article shall be deemed to have a permit pursuant to this article, upon which the secretary may prospectively impose reasonable conditions after providing the owner or operator of such facility with notice and opportunity for a hearing. Any such entity failing to comply with such prospective reasonable conditions shall be subject to all of the remedies available to the secretary pursuant to this article.

(~~c~~e) A carbon dioxide sequestration facility is hereby authorized, provided that the secretary shall first issue a permit authorizing such facility and designating the horizontal and vertical boundaries of both the surface and subsurface areas to be used for such facility. In order to issue a permit to authorize a carbon dioxide sequestration facility, the secretary must find:

(1) that, if necessary, an applicant has obtained or applied for a certificate of public convenience and necessity from the public service commission pursuant to article two, chapter twenty four of this code;

(2) that (a) the portion of the geologic formation being proposed for such facility has characteristics suitable for, or which can be made suitable for, use as a reservoir through

fracturing or other demonstrated techniques, (b) the boundaries of such facility can be established with reasonable certainty, and (c) such facility is otherwise suitable and feasible for the injection, sequestration and, if proposed, withdrawal of carbon dioxide;

(3) that the use of such facility for the sequestration of carbon dioxide will not contaminate other geologic formations containing fresh water;

(4) that such facility will not be used to inject carbon dioxide into that portion of a geologic formation being used to store natural gas within the certificated boundaries (including the protective area) of an existing natural gas storage field certificated by the federal energy regulatory commission or the public service commission;

(5) that such facility will not be used to inject carbon dioxide into a portion of a geologic formation bearing oil, natural gas, coal, coalbed methane, or other mineral in such quantity and quality as to justify commercial production of that oil, gas, coal, coalbed methane, or other mineral, unless the proposed facility operator demonstrates that, in addition to any other property rights required by this article, it is the owner in fee of such portion of a geologic formation or that it has obtained the voluntary rights from the property rights holders

of such portion of a geologic formation to inject carbon dioxide into such portion of a geologic formation.

(6) that such facility will be operated in such a manner as to protect human health and the environment; and

(7) that the quality of the carbon dioxide to be managed will not compromise the safety or structural integrity of such facility.

(~~d~~f) The secretary is authorized to establish by rule an abbreviated process for the purpose of authorizing temporary research or experimental wells for the sequestration of carbon dioxide for a finite period of time.

(~~e~~g) The secretary shall adopt legislative rules to govern the relationship between competing carbon dioxide sequestration facilities. In the event one carbon dioxide sequestration facility is interfering or may interfere with another carbon dioxide sequestration facility, the secretary shall, after notice and opportunity for hearing, resolve the dispute by requiring remediation actions, by taking enforcement actions, or by imposing such permit modifications as may be necessary to resolve the dispute and avoid future interference.

(~~f~~h) Public notice required by this subsection shall be a Class I legal advertisement in a newspaper in general circulation in a county or counties where the carbon dioxide sequestration facility will be located. The secretary shall publish public notice upon issuance of a draft permit stating where the public can review the draft permit and the nature of the public’s opportunity to comment on the draft permit. The secretary shall also issue a public notice announcing any public hearing that may be held on the draft permit. Prior to approval of any permit for such facility, the secretary may upon receipt of a written request of a person having expressed concern or objections to the proposed permit, cause a public hearing to be held in the locality where such facility is proposed to be located for the purpose of receiving comment regarding the expected or perceived impacts of such facility on the local area. The secretary shall allow at least thirty days for public comment on the draft permit. Upon request of the permit applicant, the public comment period may be extended for an additional thirty days. Further extension of the comment period may be granted by the secretary for good cause shown, but in no event may the further extension of the public comment period exceed ninety days. Public notice of a public hearing shall be given at least thirty days before the hearing. Public notice of the hearing may be given at the same time as public notice of the draft permit and the two notices may be combined. The secretary shall establish by rule the procedures applicable to such notices, including but not limited to the content of public notices, the content of the public notice of hearing, the management of public comments filed, and any and all other requirements of chapter twenty-nine-a of this code.

(~~g~~i) Notwithstanding any other provision of this code to the contrary, no agency of state government or any political subdivision may regulate any carbon dioxide sequestration facility or carbon dioxide transmission pipeline except as expressly authorized pursuant to this article.

(~~h~~j) Except as provided in article two, chapter twenty four of this code and article one, chapter twenty-four-b, the secretary shall have sole and exclusive jurisdiction and authority over all entities and property necessary to issue or to deny permits or to otherwise regulate the siting and environmental aspects of carbon dioxide sequestration facilities or carbon dioxide transmission pipelines in accordance with this article, to monitor and enforce compliance with permit conditions and the legal requirements established in accordance with this article, and to regulate any subsequent withdrawal of sequestered carbon dioxide. In exercising such jurisdiction and authority, the secretary may conduct hearings, issue and enforce orders, and adopt, modify, repeal and enforce procedural, interpretive and legislative rules in accordance with chapter twenty-nine-a of this code concerning geologic sequestration and withdrawal of carbon dioxide from carbon dioxide sequestration facilities.

(~~j~~k) The requirements of articles six and nine of this chapter shall not apply to wells subject to the requirements of this article. In addition, no well subject to the requirements of this article shall be subject to the jurisdiction of the oil and gas conservation commission, the shallow gas well review board, or the coal bed methane review board regardless of depth, well spacing, production of hydrocarbons, or otherwise. Any issues regarding depth, well spacing, setback from boundary lines, safety procedures, and production of hydrocarbons shall be subject to the sole jurisdiction of the secretary pursuant to this article. The secretary may combine the data collected for wells associated with a carbon dioxide sequestration facility into other data bases.

(~~k~~l) Any person adversely affected by an order made and entered by the secretary in accordance with the provisions of this article, or aggrieved by the failure or refusal of the secretary to act within a reasonable time on an application for a permit or aggrieved by the terms and conditions of a permit granted under the provisions of this article, may appeal to the Environmental Quality Board, pursuant to the provisions of article one, chapter twenty-two-b of this code.

(m) The secretary shall have the authority to regulate carbon dioxide transmission pipelines to the extent allowed under any article of this code other than this article.

§22-11A-45. General powers and duties of the secretary with respect to carbon dioxide sequestration.

(a) The secretary, after receiving public comment and after consultation with the state geologist and the working group established in section ~~six~~ seventeen of this article, shall promulgate legislative rules in accordance with the provisions of article three, chapter twenty-nine-a of this code to implement the provisions of this article, including, without limitation:

(1) The requirements for issuance of permits for carbon dioxide sequestration;

(2) The requirements for carbon dioxide sequestration permit applications;

(3) The issuance of notice following the approval of a permit application, which ~~shall identify the location at which the public may examine the permit, describe the nature of the public's opportunity to comment, and list any public hearing that may be held in connection with the permit. The secretary shall allow no less than thirty days for public comment on the~~

~~draft permit and may for good cause extend the comment period up to an additional thirty days. Notice of any public hearing shall be given no less than thirty days prior to its conduct~~ notice shall be in accordance with section four of this article; and

(4) The creation of subclasses of wells within the existing Underground Injection Control (UIC) program administered by the United States Environmental Protection Agency pursuant to Part C of the Safe Drinking Water Act, 42 U.S.C. §300h, *et seq.*, to protect human health, safety and the environment and to allow for the separate permitting of wells for the sequestration of carbon dioxide;

(5) The appropriate bonding or other financial assurance procedures necessary to ensure that carbon dioxide sequestration ~~sites and~~ facilities will be constructed, operated and closed in accordance with the purposes and provisions of this article; and

(6) The proper duration of the post-closure care period for carbon dioxide sequestration ~~sites~~ facilities.

(b) The secretary shall propose amendments to the rules promulgated under this section and take such action as may be required in order to fulfill the state's primary responsibility for assuring compliance with the federal Safe Drinking Water Act, including any amendments thereto.

(c) The secretary upon presentation of credentials: (i) has a right of entry to, upon or through any premises in which a carbon dioxide sequestration facility or closed sequestration facility is located or in which any records required to be maintained under this article are located; and (ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method required under this article and take such samples which the owner or operator of such facility or pipeline is required to sample under this article. Nothing in this subsection eliminates any obligation to follow any process that may be required by law.

(d) The secretary has the authority to enter at all reasonable times upon any private or public property for the purpose of making surveys, examinations, investigations and studies needed in the gathering of facts concerning the carbon dioxide sequestration facility or closed sequestration facility and its use, subject to responsibility for any damage to the property entered. Upon entering, and before making any survey, examination, investigation and study, such person shall immediately present himself or herself to the person in charge of the operation, and if he or she is not available, to a managerial employee. All persons shall cooperate fully with the person entering such property for such purposes. Upon refusal of the person owning or controlling such property to permit such entrance or the making of such surveys, examinations, investigations and studies, the secretary may apply to the circuit court of the county in which such property is located, or to the judge thereof in vacation, for an order permitting such entrance or the making of such surveys, examinations, investigations and studies; and jurisdiction is hereby conferred upon such court to enter such order upon a showing that the relief asked is necessary for the proper enforcement of this article: *Provided,* That nothing in this subsection eliminates any obligation to follow any process that may be required by law.

§22-11A-~~5~~6. Permit application requirements and contents; permit application fees.

(a) A carbon dioxide sequestration permit application shall include:

(1) A description of the general geology of the area to be affected by the injection of carbon dioxide, including geochemistry, structure and faulting, fracturing and seals, and stratigraphy and lithology, including petrophysical attributes;

(2) A characterization of the injection zone and aquifers above and below the injection zone that may be affected by the injection of carbon dioxide, including applicable pressure and

fluid chemistry data to describe the projected effects of injection activities;

(3) The identification of all other drill holes and operating wells that exist or have existed within and adjacent to the proposed sequestration site;

(4) An assessment of the effect on fluid resources, on subsurface structures and on the surface of lands that may reasonably be expected to be affected by the injection of carbon dioxide, together with the measures required to mitigate those effects;

(5) The plans and procedures for environmental surveillance and excursion detection, prevention and control programs;

(6) A site and facilities description, including a description of the proposed carbon dioxide sequestration facilities and documentation sufficient to demonstrate that the applicant has, or will have prior to the commencement of the operation, all legal rights, including without limitation the right to surface or pore space use, necessary to sequester carbon dioxide and associated constituents into the proposed carbon dioxide sequestration site;

(7) Proof that the proposed injection wells are designed, at minimum, to the construction standards set forth by the department;

(8) A plan for periodic mechanical integrity testing of all wells;

(9) A monitoring plan to assess the migration of the injected carbon dioxide and to ensure the retention of the carbon dioxide in the sequestration site;

(10) Proof of bonding or financial assurance to ensure that carbon dioxide sequestration sites and facilities will be constructed, operated and closed in accordance with the purposes and provisions of this article and the rules promulgated pursuant to this article;

(11) A detailed plan for post-closure monitoring, verification, accounting, maintenance and mitigation;

~~(12) Procedures for the operator of the facilities to provide immediate verbal notice to the department of any excursion after the excursion is discovered, followed by written notice to all surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests within thirty days of discovering the excursion~~;

~~(13) Procedures for the termination or modification of any applicable Underground Injection Control (UIC) permit issued~~

~~under Part C of the Safe Drinking Water Act, 42 U.S.C. § 300h, et seq., if an excursion cannot be controlled or mitigated;~~

(1~~4~~2) A plan to provide proof of notice to surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests regarding the contents of the application in accordance with section four of this article. ~~At a minimum, the notice shall include:~~

~~(A) The publication of a Class I legal advertisement in a newspaper of general circulation in each county of the proposed operation. The applicant shall publish the notice at the time of filing and shall identify in the notice the location where the public may examine the application;~~

~~(B) The mailing of a copy of the notice to all surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests that are located within one mile of the proposed boundary of the carbon dioxide sequestration site; and~~

(1~~5~~3) Any other requirement set forth in legislative rules promulgated under this article.

(b) Upon filing an application, an applicant shall pay a reasonable fee, as established by the secretary in legislative rules, to the department for the costs of reviewing, evaluating and processing the permit, serving notice of an application and holding any hearings. The fee ~~shall be credited to a separate account and~~ shall be used by the department as required to complete the tasks necessary to process, publish and reach a decision on the permit application.

§22-11A-7. Determination of property rights; right to inject into reservoirs within permit boundaries.

(a) The applicant must demonstrate that the applicant has, or will have prior to the commencement of the operation, all necessary legal rights, including without limitation the right to surface or reservoir use, necessary to sequester carbon dioxide and associated constituents and to transport it to the proposed carbon dioxide sequestration facility. A necessary legal right shall not include the right to use for that purpose a reservoir located at a depth of two thousand five hundred feet or more below the surface of the land which, on the effective date of a permit issued pursuant to this article, does not have a current or reasonably foreseeable use for a qualifying purpose. Such right to use such reservoirs located at a depth of two thousand five hundred feet or more below the surface is hereby declared to be a public use and no compensation shall be required to be paid solely for such use.

(b) During the permit application public comment period, potentially affected property owners shall have the opportunity to demonstrate that such facility will impair a current or reasonably foreseeable use of the reservior for a qualifying purpose. If impairment is demonstrated, the secretary shall issue a permit for such facility upon the condition that the operator:

(1) reach a contractual agreement with such owner resolving the claim;

(2) modify the carbon dioxide sequestration facility so that it avoids the impairment; or

(3) amalgamate property rights as authorized or preserved in accordance with and to the extent allowed by section eight of this article.

(c) In the absence of a showing that the reservoir proposed for use has a current or reasonably foreseeable use for a qualifying purpose that is likely to be materially impaired by the proposed facility, the public interest associated with sequestering carbon dioxide in reservoirs to help mitigate effects of climate change shall prevail over any claimed right of the owners of any rights in such reservoirs to exclude operators who are properly licensed pursuant to this article. Therefore, an operator conducting activity pursuant to a permit issued pursuant to this article for the sequestration of carbon dioxide in such reservoirs shall have the right to inject into and occupy the reservoirs within the boundaries designated by such permit in all areas in which all portions of such reservoirs are located at a depth of two thousand five hundred feet or more below the surface of the land and which, on the effective date of such permit, do not have a current or reasonably foreseeable use for a qualifying purpose at the time of permit issuance that is likely to be materially impaired by the proposed project.

(d) In the event that a property owner becomes aware of information that was not known or reasonably ascertainable at the time of the issuance of a permit under this article, the property owner may petition the secretary for a determination that the subject carbon dioxide sequestration facility will impair a then current or reasonably foreseeable use of the reservoir for a qualifying purpose. Should the secretary determine on the basis of such petition and any timely response that the subject facility will impair such use, such property owner and the owner or operator of the subject facility may submit for approval by the secretary a mutually agreeable plan that would allow for the property owner to undertake such use in a manner that would not unreasonably interfere with the subject carbon dioxide sequestration facility. The secretary shall approve the plan and modify the permit as may be appropriate to implement the plan.

§22-11A-8. Amalgamation of property rights.

(a) Except as provided in subsection (b) of this section, any owner or operator of an existing or proposed carbon dioxide sequestration facility or carbon dioxide transmission pipeline is hereby authorized to exercise the power of eminent domain or to request a pooling order pursuant to this section to acquire surface and subsurface property rights as may be necessary or useful for the purpose of constructing, operating or modifying a carbon dioxide sequestration facility or carbon dioxide transmission pipeline, including easements and rights-of-way across lands for pipelines transporting carbon dioxide to and among facilities constituting said carbon dioxide sequestration facility.

(b) No owner or operator of a carbon dioxide sequestration facility or carbon dioxide transmission pipeline may exercise the power of eminent domain or request a pooling order granted in this section:

(1) to obtain the right to inject carbon dioxide into a portion of a geologic formation bearing oil, natural gas, coal, coalbed methane, or other mineral which on the effective date of any permit from the secretary required by this article is of

such quantity and quality as to justify commercial production of that oil, natural gas, coal, coalbed methane, or other mineral;

(2) to obtain the right to inject carbon dioxide into a portion of a geologic formation located at a depth of less than two thousand five hundred feet below the surface;

(3) to obtain right of way for a pipeline to transport carbon dioxide that is withdrawn from a carbon dioxide sequestration facility to a location that is outside the boundaries of such facility; or

(4) to obtain any rights or interests in a carbon dioxide sequestration facility subject to a permit issued pursuant to this article or subject to a cooperative agreement pursuant to section eighteen of this article.

(c) The eminent domain authority authorized by this article shall be conducted pursuant to the provisions of article two, chapter fifty-four of this code.

(d) The pooling of property rights authorized by this section shall be initiated by filing with the secretary an application for an order requesting the pooling of such property rights; provided, that the applicant for pooling shall

(1) in the case of a carbon dioxide sequestration facility, own or control required property rights of at least sixty percent of the acreage (calculating partial interests on a pro rata basis for interests on any parcel owned in common) in

the reservoir within the area covered or to be covered by a permit issued pursuant to this article. Any interests owned by abandoning, missing or unknown heirs shall be excluded from the calculation of such sixty percent requirement; and

(2) in the case of a carbon dioxide transmission pipeline, own or control required property rights of at least sixty percent of the acreage (calculating partial interests on a pro rata basis for interests on any parcel owned in common) in the right of way covered or to be covered by a certificate of public convenience and necessity pursuant to this section eleven, article two, chapter twenty-four of this code. Any interests owned by abandoning, missing or unknown heirs shall be excluded from the calculation of such sixty percent requirement.

(e) The secretary shall set a hearing and provide notice to all interested parties in accordance with section four of this article with respect to a request for pooling. Each notice shall describe the area for which an order is to be entered in recognizable, narrative terms; contain such other information as is essential to the giving of proper notice, including the time and date and place of a hearing. After the hearing and upon a determination that the requirements of this section have been satisfied, the secretary shall enter an order pooling the subject property rights, authorizing the requested usage, and in the absence of a written agreement, making provisions for payment of compensation to the owners of the subject property rights upon such terms as the secretary determines is reasonable. The basis for such compensation shall be set forth in the order. The owner of the subject property rights may elect to sell its property rights by delivering a written notice to the owner of the carbon dioxide sequestration facility or carbon dioxide transmission pipeline within thirty days after entry of a pooling order pursuant to this section. In the absence of an agreement on the price to be paid, the secretary shall establish the price after notice and opportunity for hearing. Any such election or hearing shall not delay the effectiveness of the pooling order. The secretary shall enter an order granting the request for pooling, dismissing the application, or for good cause, continuing the application process within forty-five days after the filing of an application.

(f) The right of eminent domain or pooling set out in this section shall not prejudice the rights of the owners of other rights or interests therein as to all other uses not acquired for the carbon dioxide sequestration facility or carbon dioxide transmission pipeline.

(g) The eminent domain authority authorized under this section shall be in addition to any other power of eminent domain authorized by law.

(h) Notwithstanding any other provision of this code to the contrary, with respect to a condemnation petition filed in a circuit court pursuant to the provisions of this section or an application for pooling filed with the secretary pursuant to the provisions of this section, it shall be sufficient for the applicant to file the petition or application, as appropriate, against one or more parcels of land, or interests therein, and to serve notice of the action upon those persons and entities listed in the sheriff's tax records as the owners of the surface and mineral estates in the affected property, updated by examination of documents duly recorded in the office of the clerk of the county commission only from the date of the last tax assessment. Service upon out-of-state residents shall be sufficient if mailed to the address shown in the tax records, as updated, by first class mail, postage pre-paid. An affidavit of service or other proof of service shall be filed as a part of the record of the condemnation or pooling action, as appropriate. The applicant shall also publish notice of the action as a Class 1 legal advertisement in a newspaper of general circulation in county or counties in which affected property is located. The proofs of service and proof of publication shall be filed as a part of the record of the condemnation or pooling action, as appropriate. Any person or entity not served but claiming an interest in any of the properties may intervene within thirty days after publication of the notice and assert a claim. No applicant following this procedure shall have any liability on account of the condemnation or pooling, as appropriate, to any person or entity not listed in the sheriff's tax records, updated only as aforesaid, or not intervening in the condemnation or pooling proceedings, as appropriate.

(i) The request for pooling may be filed concurrently with an application for or subsequent to issuance of a permit from the secretary required by this article A certified copy of any order authorizing pooling shall be recorded by the applicant in the office of the clerk of the county commission of each county in which property rights are pooled.

(j) The power of eminent domain may be exercised after obtaining any permit from the secretary required by this article and any certificate of public convenience and necessity from the public service commission as provided in section eleven-e, article two, chapter twenty-four of this code.

§22-11A-9. Inverse condemnation; common law claims.

The sole remedy of the owner of a property right who claims that the use of such property right by a carbon dioxide sequestration facility is a per se physical taking of property without just compensation shall be to file an inverse condemnation action to obtain just compensation. In such event, the operator shall not be liable under common law for trespass, nuisance, or any other common law claim.

§22-11A-~~8~~10. Oil, natural gas and coalbed methane activities at carbon dioxide sequestration ~~sites~~ facility; extraction of sequestered carbon dioxide.

(a) Nothing in this article shall be deemed to affect the otherwise lawful right of a ~~mineral owner~~ person to drill or bore through or to otherwise exercise rights near a carbon dioxide sequestration ~~site~~ facility, if done in accordance with the rules promulgated under this article for protecting the carbon dioxide sequestration ~~site~~ facility against the escape of carbon dioxide.

(b) Nothing in this article is intended to impede or impair the ability of an oil, natural gas or coalbed methane operator to inject carbon dioxide through an approved enhanced oil, natural gas or coalbed methane recovery project and to establish, verify, register and sell emission reduction credits associated with the project.

(c) The ~~Office of Oil and Gas~~ secretary shall have jurisdiction over any subsequent extraction of sequestered carbon dioxide that is intended for commercial or industrial purposes.

(d) Except as herein specifically provided, nothing in this article shall alter or amend existing state law regarding correlative property rights or the primacy of the oil, natural gas, coal, coalbed methane or other mineral estate.

(e) Title to the carbon dioxide injected into and stored in a carbon dioxide sequestration facility is vested in the owner or operator of such facility, and such owner or operator retains title throughout the operational life of such facility, and until the secretary issues a certificate of completion.

(f) Once the secretary has issued a certificate of completion, title to the carbon dioxide sequestered in a carbon dioxide sequestration facility transfers to the owner of the right to use the reservoir unless that owner cannot be determined in which case title to such carbon dioxide transfers to the owner of the surface estate.

(g) Any extraction for profit of carbon dioxide sequestered in a carbon dioxide sequestration facility shall be undertaken only with the agreement of the owner of the right to use the reservoir or the owner of the surface estate in the event the owner of the right to use the reservoir cannot be determined. Any extraction of carbon dioxide sequestered in a carbon dioxide sequestration facility for the purpose of remediation or for the protection of human health or the environment may be undertaken without the agreement of such owner.

(h) Except as herein specifically provided, nothing in this article shall alter, amend, diminish or invalidate rights to use a reservoir that was acquired by contract or lease prior to the effective date of this article, including, without limitation, rights acquired for the underground storage of natural gas, or in connection with the extraction or production of oil, natural gas, coal, coalbed methane or other minerals, including, without limitation, rights for the secondary recovery of coal, oil, natural gas, coalbed methane or other minerals by injection of carbon dioxide or water or by other means.

§22-11A-11. Carbon dioxide sequestration facility operational fund.

(a) In lieu of any other fees that may otherwise be charged by the secretary, sequestration operators shall pay an operational fee established by the secretary in a legislative rule. The amount of the fee shall be based on the anticipated expenses that the department will be reasonably expected to incur in regulation of a carbon dioxide sequestration facility pursuant to this article during the construction, operational, and pre-closure phases of such facilities. The total amount of the fee so assessed may not exceed the lesser of one hundred and fifty thousand dollars per year or one cent per metric tonne of carbon dioxide injected for sequestration. The operational fee may also include an additional amount based upon the anticipated expenses that regulatory agencies other than the department will be reasonably expected to incur in regulation of a carbon dioxide sequestration facility permitted pursuant to this article. The operational fee shall be maintained in a fund to be called the carbon dioxide sequestration facility operational fund. The fund must be maintained as a special fund and all money or interest in the fund shall be used solely for defraying the cost of expenses that regulatory agencies actually incurred in regulation of carbon dioxide sequestration facilities pursuant to this article during the construction, operational, and pre-closure phases of such facilities.

(b) All unexpended permit fees and the net proceeds of all fines, penalties and bond forfeitures collected under this article shall also be paid into the carbon dioxide sequestration operational fund. Interest earned by the fund must be deposited in the fund.

(c) The secretary, through a cooperative agreement with another state regulatory agency, in this or another state, may use the fund to compensate the cooperating agency for expenses the cooperating agency incurs in carrying out regulatory responsibilities that agency may have over a carbon dioxide sequestration facility regulated pursuant to this article during the construction, operational, and pre-closure phases of such facility.

(d) No less frequently than every five years, the secretary shall review, and revise as appropriate, the operational fee authorized by this section to assure that the fee meets the requirements of this section.

(e) Any funds held by the carbon dioxide sequestration facility operational fund in excess of the amounts needed to accomplish the purposes of this section shall be deposited in the carbon dioxide sequestration facility post-closure trust fund established pursuant to section fourteen of this article. In no event shall such excess funds be transferred to the state's general revenue fund or elsewhere.

(f) The secretary is hereby authorized to promulgate rules and regulations related to the setting and collection of fees pursuant to this section.

§22-11A-12. Limitations on claims and liabilities during the operational phase.

(a) In any civil liability action against the owner or operator of a carbon dioxide sequestration facility, or carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, the maximum amount recoverable as compensatory damages for noneconomic loss shall not exceed two hundred fifty thousand dollars per occurrence, except where the damages for noneconomic loss suffered by the plaintiff were for: (1) wrongful death; (2) permanent and substantial physical deformity, loss of use of a limb or loss of a bodily organ system; or (3) permanent physical or mental functional injury that permanently prevents the injured person from being able to independently care for himself or herself and perform life sustaining activities. In such cases, the maximum amount recoverable as compensatory damages for noneconomic loss shall not exceed five hundred thousand dollars per occurrence.

(b) If subsection (a) of this section, or the application thereof to any person or circumstance, is found by a court of law to be unconstitutional or otherwise invalid, the maximum amount recoverable as damages for noneconomic loss under either subsection shall thereafter not exceed one million dollars per occurrence.

(c) In any civil liability action against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, punitive damages cannot be recovered unless intentional and reprehensible conduct is proven by clear and convincing evidence; provided, however, that in no event shall the amount recoverable as punitive damages exceed one million dollars.

(d) All causes of action alleging injury to person or property arise as of the date of injury and must be commenced within two years of the date of such injury, or within two years of the date when such person discovers, or with the exercise of reasonable diligence should have discovered, such injury, whichever last occurs; provided, that in no event shall any such action be commenced more than ten years after the date of injury.

(e) The periods of limitation set forth in subsection (d) shall be tolled as to any owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline for any period during which it is demonstrated by clear and convincing evidence that any such owner, operator or generator intentionally and knowingly concealed or intentionally and knowingly misrepresented material facts related to the mechanical integrity of the carbon dioxide sequestration facility, the chemical composition of any injected carbon dioxide, or the injury.

(f) If the trier of fact renders a verdict for the plaintiff, the court shall enter judgment of several, but not

<u>joint, liability against each defendant in accordance with the percentage of fault attributed to the defendant by the trier of fact.</u>

<u>(g) Notwithstanding any other provision of this code, in all civil liability actions against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility of pipeline, and in all public liability actions against the state, regardless of the theory of liability under which they are commenced, the total amount of compensatory damages awarded to a plaintiff in such action shall be reduced by any collateral source payments made or to be made to the plaintiff, except insurance for which the plaintiff, spouse of the plaintiff or parent of the plaintiff has paid the entire premium, insurance that is subject to a right of subrogation, workers' compensation benefits that are subject to a right of subrogation, or insurance that has any other obligation of repayment. The reduction in compensatory damages shall be determined by the court after the verdict and before entry of judgment, and reduction may be made only if the collateral source payments are compensation for the same damages recovered by the verdict. No evidence of collateral source payments may be admitted during trial. After considering the evidence related to collateral source submitted by any party,</u>

the court shall make a determination as to the amount by which a plaintiff’s compensatory damages will be reduced by any such collateral source payments.

(h) Notwithstanding the case of Bower v. Westinghouse, 552 S.E.2d 424 (W. Va. 1999), in any civil liability action against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, and in any public liability action against the state, a plaintiff may not recover for future medical monitoring, testing, examination, treatment, services, surveillance, or procedures of any kind, including the costs and expenses associated therewith, unless such future medical monitoring, testing, examination, treatment, services, surveillance or procedures are directly related to a present manifestation of physical injury or disease which was caused by or directly related to the tortious or wrongful act of the carbon dioxide sequestration facility owner or operator, carbon dioxide sequestration pipeline operator, carbon dioxide sequestration generator, or the state and which was found to have caused the present physical impairment.

(i) Notwithstanding any other provision of law, absent privities of contract, no plaintiff who files a civil liability action against the owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility of pipeline, or who files a public liability action against the state, may file an independent cause of action against any insurer of the owner or operator of a sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility or pipeline, or the state, alleging the insurer has violated the provisions of section three, article eleven, chapter thirty-three of this code or subdivision nine, section four, article eleven, chapter thirty-three of this code.

(j) No owner or operator of a carbon dioxide sequestration facility, carbon dioxide transmission pipeline, or the generator of the carbon dioxide being handled by either such facility of pipeline, nor the state, may file a cause of action against their own insurer alleging the insurer has violated the provisions of section three, article eleven chapter thirty-three of this code, or subdivision nine, section four, article, eleven, chapter thirty-three of this code, until there has been a verdict in the underlying action or the case has otherwise been dismissed, resolved or disposed.

§22-11A-13. Carbon Dioxide Management Authority.

(a) There is hereby established an independent agency of the state of West Virginia to be known as the Carbon Dioxide Management Authority. The authority shall consist of three members appointed by the Governor by and with the advice and consent of the Senate for terms of three years. No more than two of the members may at any one time belong to the same political party. One member shall be a person with significant experience in environmental protection. All members of the authority shall be citizens of the state of West Virginia. A member appointed to fill an unexpired term shall serve only for the remainder of that term. Members of the authority shall be reimbursed for reasonable expenses incurred in the discharge of official duties. All expenses incurred by the authority shall be paid in a manner consistent with guidelines of the Travel Management Office of the West Virginia Department of Administration.

(b) The authority shall provide the following functions—

(1) prescribe the form of cost reimbursement agreements, offer such agreements to the secretary with stewardship responsibility, and execute such agreements on behalf of the State of West Virginia,

(2) prescribe compensation schedules and remediation standards,

(3) determine the extent to which public liability claims filed with the authority are payable under applicable compensation schedules,

(4) determine whether remediation actions are required at a closed sequestration facility under the authority's remediation standards,

(5) make payments under cost reimbursement agreements (including payments for remediation costs), and

(6) exercise such other authorities as may be necessary or appropriate to carry out its functions under the preceding subdivisions of this subsection or other provisions of this article, including employment of personnel and entering into contracts.

(c) The authority shall offer the secretary, upon issuance of a certificate of completion, stewardship responsibility for a closed sequestration facility, a contract under which the authority provides reimbursement for costs of monitoring, administration, and remediation of such facility. The authority shall prescribe rules for reimbursement of all reasonable costs of operation, administration, and remediation incurred by the secretary with stewardship responsibility for closed sequestration facilities.

(d) The authority shall prescribe standards for determining whether and to what extent remediation will be required at a closed sequestration facility in order to protect health, safety, or the environment, and the payments for such remediation shall be made from the Carbon Dioxide Sequestration Facility Trust Fund in accordance with the contracts under section sixteen of this article.

(e) The authority shall be responsible for the payments authorized by this article until such time as the federal government assumes responsibility for the long-term monitoring and management of carbon dioxide sequestration facilities.

(f) The authority shall procure insurance coverage for each sequestration facility owned by the state, if and to the extent such a policy is available, that insures against losses stemming from a public liability action arising from the closed sequestration facility. The insurance coverage shall be in an amount determined by regulation. The authority shall pay any insurance premiums and deductibles of the insurance policies procured under this section from the Carbon Dioxide Sequestration Facility Post-Closure Trust Fund.

(g) The authority or the secretary upon authorization of the authority may by rule or order prescribe requirements for monitoring closed sequestration facilities and for making such inspections and reports as may be necessary or appropriate to carry out this article. The authority may on its own, or authorize the secretary, to enter onto the premises or property of any closed sequestration facility to carry out the requirements of this article.

(h) The authority is authorized to enter into agreements and contracts and to expend money in the post-closure trust fund for the following purposes:

(1) to monitor closed sequestration facilities;

(2) to remediate and repair mechanical problems at the closed sequestration facility;

(3) to plug and abandon remaining wells under the jurisdiction of the department of environmental protection except for those wells to be used as observation wells;

(4) to pay premiums and deductibles under any insurance policy purchased in accordance with this article; and

(5) to pay the portion of any public liability claim as authorized by this article; provided that no portion of the money in the trust fund shall be used to defray the costs of administering this article.

(6) to compensate, through a cooperative agreement with another state regulatory agency in this or another state, the cooperating agency for expenses the cooperating agency incurs in

carrying out the regulatory responsibilities that agency may have over a closed sequestration facility regulated pursuant to this article during the post-closure phase of such facility.

(i) The authority, after consultation with the secretary, shall by rule prescribe compensation schedules for determining the nature and amount of compensation that will be paid from the Carbon Dioxide Sequestration Post-Closure Trust Fund for public liability claims.

(j) The authority is hereby authorized to promulgate rules or authorize the secretary to promulgate rules related to the setting and collection of post-closure fees.

(l) Rules of general applicability prescribed under this article by the secretary or the authority shall be reviewed in the same manner provided in section nine, article one, chapter twenty-two-b of this code.

§22-11A-14. Establishment of Post-closure Trust Fund, Post-closure fee.

(a) There is hereby established the Carbon Dioxide Sequestration Facility Post-closure Trust Fund to be administered by the Carbon Dioxide Management Authority.

(b) Sequestration operators shall pay a post-closure fee on each metric tonne of carbon dioxide injected for sequestration, which shall be imposed periodically during the operational phase of the project. The fee shall be in the amount established by the authority in a legislative rule. The trust fund shall be utilized for the administration of closed sequestration facilities and may not exceed seven cents per metric tonne of carbon dioxide injected for sequestration. The post-closure fee shall be maintained in the trust fund established under subsection (a) of this section which shall be maintained as a special fund and all money or interest in the fund shall be used for the purpose set forth in this article.

(c) Interest earned by the fund must be deposited in the fund.

(d) Once any single sequestration operator has contributed fifty million dollars to the trust fund, the fee assessments to that sequestration operator under this section shall cease. The authority shall on its own accord or authorize the secretary to promulgate by legislative rule the nature and extent to which such fee may be reduced to account for the existence of multiple facilities and to assure that the trust fund contains only enough as can be justified on the basis of an actuarially determined assessment of risk.

(e) No less frequently than every five years, the authority shall review, and revise as appropriate, the per metric tonne post-closure fee authorized by this section to assure that the fee meets the requirements of this section.

§22-11A-15. Stewardship responsibility for closed sequestration facilities.

(a) The secretary shall, after notice and opportunity for comment, assume stewardship responsibility for closed sequestration facilities in West Virginia in accordance with the provisions of this article until such time as the federal government assumes responsibility for the long-term stewardship of carbon dioxide sequestration facilities.

(b) Upon issuance of the certificate of completion for a carbon dioxide sequestration facility, the secretary shall be responsible for continued monitoring of that facility, and for any remediation that is required by the authority or that the secretary determines is necessary and is authorized by the authority. The secretary's costs of monitoring, program administration, and remediation shall be reimbursed by the authority from the carbon dioxide sequestration facility post-closure trust fund pursuant to a reimbursement contract under this article.

§22-11A-16. Transfer of liability during the post closure phase.

(a) Unless the secretary allows an earlier filing, for good cause shown, the owner or operator of a carbon dioxide sequestration facility may apply for a certificate of completion of injection operations no earlier than ten years after the cessation of operation related to the injection of carbon dioxide into such facility. The secretary shall issue a certificate of completion of injection operations upon a showing by the project operator that such facility has been closed in accordance with an approved closure plan, and the reservoir is reasonably expected to retain mechanical integrity and the carbon dioxide is reasonably expected to remain emplaced. Upon the issuance of the certificate of completion, ownership of such facility shall transfer to the West Virginia Carbon Dioxide Management Authority.

(b) Upon issuance of the certificate of completion for a carbon dioxide sequestration facility:

(1) all public liability claims related to that facility and arising or accruing on and after the date on which the certificate of completion was issued shall be filed against the authority, and

(2) the project operator of such facility, the owner of such facility, any carbon dioxide transmission pipeline that transported carbon dioxide to such facility, the owner of the carbon dioxide sequestered in such facility, the owner of the reservoir in which the carbon dioxide is being sequestered and

the generator of the carbon dioxide being handled by either such facility or pipeline shall not be subject to any civil liability claim after the issuance of the certificate of completion, unless it is demonstrated by clear and convincing evidence that any such operator, owner, or generator intentionally and knowingly concealed or intentionally and knowingly misrepresented material facts related to the mechanical integrity of the carbon dioxide sequestration facility or the chemical composition of any injected carbon dioxide.

(c) The secretary has stewardship responsibility for a closed carbon dioxide sequestration facility; however, the secretary shall not be subject to any civil liability claim as a result of its assuming stewardship responsibility.

§ 22-11A-17. Carbon dioxide sequestration working group.

(a) The secretary shall establish the carbon dioxide sequestration working group.

(b) The secretary, in cooperation with the state geologist, shall appoint at least fifteen persons to serve on the working group.

(c) In selecting persons to serve on the working group, the secretary and the state geologist shall appoint at least three persons who are experts in carbon dioxide sequestration or related technologies, at least one person who is an expert in environmental science, at least one person who is an expert in geology, at least one person who is an attorney with an expertise in environmental law, at least one person who is an expert in engineering, at least one person who is an expert in the regulation of public utilities in West Virginia, one person who is a representative of a citizen's group advocating environmental protection, a representative of a coal power electric generating utility advocating carbon dioxide sequestration development, at least one person who is an engineer with an expertise in the underground storage of natural gas, the chairman of the National Council of Coal Lessors or his/her designee, a representative of the West Virginia Coal Association, a representative of the West Virginia Land and Mineral Owners Association, and at least one representative advocating the interests of surface owners of real property.

(d) The working group shall study issues pertaining to carbon dioxide sequestration including, but not limited to, scientific, technical, legal and regulatory issues, and issues regarding ownership and other rights and interests in subsurface space that can be used as storage space for carbon dioxide and other associated constituents, or other substances, commonly referred to as "pore space," and shall report to the secretary and the Legislature its recommendations with respect to the development, regulation and control of carbon dioxide sequestration and related technologies.

(e) In addition, the working group shall develop a long-term strategy for carbon dioxide sequestration in West Virginia.

(f) The working group may conduct or initiate studies, scientific or other investigations, research, experiments and demonstrations pertaining to carbon dioxide sequestration, and to this end, the working group may cooperate with state institutions of higher education or any public or private agency. The secretary may receive on behalf of the state for deposit in the State Treasury any moneys which such institutions or state agencies may be authorized to transfer to the secretary, and all gifts, donations or contributions which such private agencies or others may provide, to defray the expenses of the working group. Any amounts so received shall be expended by the secretary solely for the purposes set forth in subsection (d) of this section.

~~(g) The working group shall issue a preliminary report to the secretary and the Legislature by July 1, 2010, containing any preliminary recommendations or findings of the working group.~~

~~(h) The working group shall issue a final report to the Legislature by July 1, 2011, which report shall, at a minimum:~~

~~(1) Recommend appropriate methods to encourage the development of carbon dioxide sequestration technologies;~~

~~(2) Assess the economic and environmental feasibility of large, long-term carbon dioxide sequestration operations;~~

~~(3) Recommend any legislation the working group may determine to be necessary or desirable to clarify issues regarding the ownership and other rights and interest in pore space;~~

~~(4) Recommend methods of facilitating the widespread use of carbon dioxide sequestration technology throughout West Virginia;~~

~~(5) Identify geologic sequestration monitoring sites to assess the short-term and long-term impact of carbon dioxide sequestration;~~

~~(6) Assess the feasibility of carbon dioxide sequestration in West Virginia and the characteristics of areas within the state where carbon dioxide could be sequestered;~~

~~(7) Assess the costs, benefits, risks and rewards of large-scale carbon dioxide sequestration projects in West Virginia;~~

~~(8) Assess the potential carbon dioxide sequestration capacity in this state;~~

~~(9) Identify areas of research needed to better understand and quantify the processes of carbon dioxide sequestration; and~~

~~(10) Outline the working group's long-term strategy for the regulation of carbon dioxide sequestration in West Virginia.~~

~~(i) The working group, along with the state geologist, shall assist the secretary in developing and promulgating legislative rules under this article.~~

(g) In addition to its other responsibilities under this article, the working group shall for a period of five years from the effective date of this section:

(1) Consult with and advise the secretary and authority on program and policy development, problem solving, rulemaking, and other appropriate subjects; and

(2) Identify and define problems associated with the implementation of the policy set forth in section two of this article;

§22-11A-18. Cooperative agreements.

(a) The secretary is authorized to enter into cooperative agreements with other governments or government entities for the purpose of regulating carbon dioxide ~~storage projects~~ sequestration facilities or carbon dioxide transmission pipelines that extend beyond state regulatory authority under this article.

(b) If a cooperative agreement is entered into by the secretary with another state or government entity and the state or government entity has similar laws or regulations regarding permit requirements for a carbon dioxide sequestration facility or a carbon dioxide transmission pipeline, exercising the right of eminent domain, authorization for the use of pore space, post closure liability transfer, and the funding of administrative and liability issues, then persons holding a permit authorizing a carbon dioxide sequestration facility issued by the other state or government entity are authorized to use pore space in this state, unitize property, and to exercise the power of eminent domain to acquire surface and subsurface rights and property interests as provided in this article in accordance with the terms of such cooperative agreement.

§22-11A-19. Reporting and accountability.

(a) Every five years the secretary shall submit a report to the Legislature which assesses the effectiveness of this article and provides such other information as may be requested by the Legislature to allow the Legislature to assess the effectiveness of this article, including without limitation ~~The department shall include within the reports to the Legislature required by section six, article twelve of this chapter its~~ the secretary's observations concerning all aspects of compliance with this article, ~~including without limitation~~ the promulgation of rules, ~~the formation of the carbon dioxide sequestration working group,~~ the permitting process and any pertinent changes to federal rules or regulations.

(b) The secretary shall keep accurate accounts of all receipts and disbursements related to the administration of the carbon dioxide sequestration facility operational fund and shall make a specific annual report addressing the administration of the fund.

(c) The authority shall keep accurate accounts of all receipts and disbursements related to the administration of the carbon dioxide sequestration facility post-closure trust fund and shall make a specific annual report addressing the administration of the fund.

§22-11A-20. Civil, administrative, and criminal penalties; compliance orders.

(a) Any person who violates any provision of this article, or any permit or agency approval, rule or order issued to implement this article, is subject to civil penalties in accordance with the provisions of section twenty-two, article eleven of this chapter: Provided, That such penalties are in lieu of civil penalties which may be imposed under other provisions of this code for the same violation.

(b) Any person who willfully or negligently violates any provision of this article, or any provision of a permit or agency approval, rule or order issued to implement this article, is subject to criminal penalties in accordance with the provisions of section twenty-four, article eleven of this chapter: Provided, That such penalties are in lieu of other criminal penalties which may be imposed under other provisions of this code for the same violation.

(c) Any person who violates any provision of this article, or any permit or rule or order issued to implement this article, is subject to a civil administrative penalty to be levied by the secretary or the authority, as appropriate, of not more than five thousand dollars a day per violation, the total penalty for such violation shall not exceed twenty thousand dollars. No combination of assessments against any violator under this section may exceed twenty-five thousand dollars per day. In assessing any such penalty, the secretary or authority, as appropriate, shall take into account the seriousness of the violation and any good faith efforts to comply with applicable requirements as well as any other appropriate factors as may be established by such official by legislative rules promulgated pursuant to this article and the provisions of chapter twenty-nine-a of this code. No assessment may be levied pursuant to this subsection until after the alleged violator has been notified by such official by certified mail or personal service. The notice shall include a reference to the section of the statute, rule, order or statement of permit conditions that was allegedly violated, a concise statement of the facts alleged to constitute the violation, a statement of the amount of the administrative penalty to be imposed and a statement of the alleged violator's right to an informal hearing. The alleged violator shall have twenty calendar days from receipt of the notice within which to deliver to such official a written request for an informal hearing. If no hearing is requested, the notice becomes a final order after the expiration of the twenty-day period. If a hearing is requested, the secretary or authority, as appropriate, shall inform the alleged violator of the time and place of the hearing. The secretary or authority, as appropriate, may appoint an assessment officer to conduct the informal hearing who shall make a written recommendation to such official concerning the assessment of a civil administrative penalty. Within thirty days following the informal hearing, the secretary or authority, as appropriate, shall issue and furnish to the violator a written decision, and the reasons therefore, concerning the assessment of a civil administrative penalty. Within thirty days after notification of the secretary's or authority's, as appropriate, decision, the alleged violator may request a formal hearing before the environmental quality board in accordance with the provisions of this article. Any administrative civil penalty assessed pursuant to this section is in lieu of any other civil penalty which may be assessed under any provision of this code for the same violation. All administrative penalties shall be levied in accordance with legislative rules promulgated by such official in accordance with the provisions of chapter twenty-nine-a of this code.

(d) The net proceeds of all civil penalties collected pursuant to this section and all assessments of any civil administrative penalties collected pursuant to this section shall be deposited into the carbon dioxide sequestration facility post-closure trust fund established pursuant to this article.

(e) The secretary or authority, as appropriate, may seek an injunction, or may institute a civil action against any person in violation of any provision of this article or any permit, agency approval, rule or order issued to implement this article. In seeking an injunction, it is not necessary for the secretary or authority, as appropriate, to post bond nor to allege or prove at any point in the proceeding that irreparable damage will occur if the injunction is not issued or that the remedy at law is inadequate. An application for injunctive relief or a civil penalty action under this section may be filed and relief granted notwithstanding the fact that all administrative remedies provided for in this article have not been exhausted or invoked against the person or persons against whom such relief is sought.

(f) If the secretary or authority, as appropriate, upon inspection, investigation or through other means observes, discovers or learns of a violation of the provisions of this article, or any permit, order or rules issued to implement the provisions of this article, he or she may issue an order stating with reasonable specificity the nature of the violation and requiring compliance immediately or within a specified time. An order under this section includes, but is not limited to, any or all of the following: Orders implementing this article which (1) suspend, revoke or modify permits; (2) require a person to take remedial action; or (3) are cease and desist orders.

(g) Any person issued a cease and desist order under subsection (f) of this section may file a notice of request for reconsideration with the secretary or authority, as appropriate, not more than seven days from the issuance of such order and shall have a hearing before such official to contest the terms and conditions of such order within ten days after filing such notice of a request for reconsideration. The filing of a notice of request for reconsideration does not stay or suspend the execution or enforcement of such cease and desist order.

§22-11A-21. Confidentiality.

(a) Information required to be submitted by a project operator or owner pursuant to this article that may be a trade secret, contain protected information relating to homeland security or be subject to another exemption provided by the state freedom of information act may be deemed confidential. Each such document shall be identified by that person as confidential information. The person claiming confidentiality shall provide written justification to the secretary at the time the information is submitted stating the reasons for confidentiality and why the information should not be released or made public. The secretary has the discretion to approve or deny requests for confidentiality as prescribed by this section.

(b) In addition to records or documents that may be considered confidential under article one, chapter twenty-nine-b of this code, confidential information means records, reports or information, or a particular portion thereof, that if made public would:

(1) Divulge production or sales figures or methods, processes or production unique to the submitting person;

(2) Otherwise tend to adversely affect the competitive position of a project operator or owner by revealing trade secrets, including intellectual property rights; or

(3) Present a threat to the safety and security of any water supply, including information concerning water supply vulnerability assessments.

(c) Information designated as confidential and the written justification shall be maintained in a file separate from the general records related to the person.

(d) Information designated as confidential may be released when the information is contained in a report in which the identity of the person has been removed and the confidential information is aggregated by hydrologic unit or region.

(e) Information designated as confidential may be released to governmental entities, their employees and agents when compiling and analyzing survey and registration information and as may be necessary to develop the legislative report required by this section or to develop water resources plans. Any governmental entity or person receiving information designated confidential shall protect the information as confidential.

(f) Upon receipt of a request for information that has been designated confidential and prior to making a determination to grant or deny the request, the secretary shall notify the person claiming confidentiality of the request and may allow the project operator or owner an opportunity to respond to the request in writing within five days.

(g) All requests to inspect or copy documents shall state with reasonable specificity the documents or type of documents sought to be inspected or copied. Within ten business days of the receipt of a request, the secretary shall: (1) Advise the project operator or owner making the request in writing of the time and place where the project operator or owner may inspect and copy the documents which, if the request addresses information claimed as confidential, may not be sooner than twenty days following the date of the determination to disclose, unless an earlier disclosure date is agreed to by the project operator or owner claiming confidentiality; or (2) deny the request, stating in writing the reasons for denial. If the request addresses information claimed as confidential, then notice of the action taken pursuant to this subsection shall also be provided to the project operator or owner asserting the claim of confidentiality.

(h) Any project operator or owner adversely affected by a determination regarding confidential information under this article may appeal the determination to the appropriate circuit court pursuant to the provisions of article five, chapter twenty-nine-a of this code. The filing of a timely notice of appeal shall stay any determination to disclose confidential information pending a final decision on appeal. The scope of review is limited to the question of whether the portion of the records, reports, data or other information sought to be deemed confidential, inspected or copied is entitled to be treated as confidential under this section. The secretary shall afford evidentiary protection in appeals as necessary to protect the confidentiality of the information at issue, including the use of in camera proceedings and the sealing of records when appropriate.

§22-11A-22.Severability.

If any provision of this article or its application to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of this article which can be given effect without the invalid provision or application, and to this end the provisions of this article are severable.

CHAPTER 22 ENVIRONMENTAL RESOURCES

ARTICLE 12. GROUNDWATER PROTECTION ACT

§22-12-5. Authority of other agencies; applicability.

(a) Notwithstanding any other provision of this code to the contrary, no agency of state government or any political subdivision may regulate any facility or activities for the purpose of maintaining and protecting the groundwater except as expressly authorized pursuant to this article.

(b) To the extent that such agencies have the authority pursuant to any provision of this code, other than this article, to regulate facilities or activities, the division of environmental protection, the department of agriculture, the bureau of public health, and such agencies of the state or any political subdivision as may be specifically designated by the director with the concurrence of such designated agencies or political subdivisions, as appropriate, are hereby authorized to be groundwater regulatory agencies for purposes of regulating such facilities or activities to satisfy the requirements of this article. In addition, the department of agriculture is hereby authorized to be the groundwater regulatory agency for purposes of regulating the use or application of pesticides and fertilizers. Where the authority to regulate facilities or activities which may adversely impact groundwater is not otherwise assigned to the division of environmental protection, the department of agriculture, the bureau of public health or such other specifically designated agency pursuant to any other provision of this code, the division of environmental protection is hereby authorized to be the groundwater regulatory agency with respect to such unassigned facilities or activities. The division of environmental protection shall cooperate with the department of agriculture and the bureau of public health, as appropriate, in the regulation of such unassigned facilities or activities.

(c) Within one year of the effective date of this article, the department of agriculture, bureau of public health and division of environmental protection shall promulgate in accordance with the provisions of chapter twenty-nine-a of this code such legislative rules as may be necessary to implement the authority granted them by this article.

(d) Groundwater regulatory agencies shall develop groundwater protection practices to prevent groundwater contamination from facilities and activities within their respective jurisdictions consistent with this article. Such practices shall include, but not be limited to, criteria related to facility design, operational management, closure, remediation, and monitoring. Such agencies shall issue such rules, permits, policies, directives or any other appropriate regulatory devices, as necessary, to implement the requirements of this article.

(e) Groundwater regulatory agencies shall take such action as may be necessary to assure that facilities or activities within their respective jurisdictions maintain and protect groundwater at existing quality, where the existing quality is better than that required to maintain and protect the standards of purity and quality promulgated by the board to support the present and future beneficial uses of the state's groundwater.

(f) Where a person establishes to the director that (1) the measures necessary to preserve existing quality are not technically feasible or economically practical and (2) a change in groundwater quality is justified based upon economic or societal objectives, the director may allow for a deviation from such existing quality. Upon the director's finding of (1) and (2) above, the director may grant or deny such a deviation for a specific site, activity or facility or for a class of activities or facilities which have impacts which are substantially similar and exist in a defined geographic area. The director's reasons for granting or denying such a deviation shall be set forth in writing and the director has the exclusive authority to determine the terms and conditions of such a deviation. To insure that groundwater standards promulgated by the board are not violated and that the present and future beneficial uses of groundwater are maintained and protected, the director shall evaluate the cumulative impacts of all facilities and activities on the groundwater resources in question prior to any granting of such deviation from existing quality. The director shall consult with the department of agriculture and the bureau of public health as appropriate in the implementation of this subsection. The director shall, upon a written request for such information, provide notice of any deviations from existing quality granted pursuant to this subsection.

(g) Should the approval required in subsection (f) of this section be granted allowing for a deviation from existing quality, the groundwater regulatory agencies shall take such alternative action as may be necessary to assure that facilities and activities within their respective jurisdictions maintain and protect the standards of purity and quality promulgated by the board to support the present and future beneficial uses for that groundwater. In maintaining and protecting such standards of the board, such agencies shall establish preventative action limits which, once reached, shall require action to control a source of contamination to assure that such standards are not violated. The director shall provide guidelines to the groundwater regulatory agencies with respect to the establishment of such preventative action limits.

(h) Subsections (e), (f) and (g) of this section do not apply to coal extraction and earth disturbing activities directly involved in coal extraction that are subject to either or both article three or eleven of this chapter. Such activities are subject to all other provisions of this article.

(i) This article is not applicable to groundwater within ~~areas~~ those portions of geologic formations which are site specific to:

(1) The production or storage zones of crude oil or natural gas and which are utilized for the exploration, development or production of crude oil or natural gas permitted pursuant to articles six, seven, eight, nine or ten of this chapter; and

(2) The injection zones of Class II, ~~or~~ III, or VI wells permitted pursuant to the statutes and rules governing the underground injection control program.

(3) The injection zones of all other wells otherwise permitted pursuant to the statutes and rules governing carbon sequestration.

All groundwater outside such areas remain subject to the provisions of this article. Groundwater regulatory agencies have the right to require the submission of data with respect to the nature of the activities subject to this subsection.

CHAPTER 24. PUBLIC SERVICE COMMISSION

ARTICLE 2. POWERS AND DUTIES OF PUBLIC SERVICE COMMISSION

§24-2-1. Jurisdiction of commission; waiver of jurisdiction.

(a) The jurisdiction of the commission shall extend to all public utilities in this state and shall include any utility engaged in any of the following public services:

Common carriage of passengers or goods, whether by air, railroad, street railroad, motor or otherwise, by express or otherwise, by land, water or air, whether wholly or partly by land, water or air; transportation of oil, gas or water by pipeline; transportation of carbon dioxide by pipeline to carbon dioxide sequestration facilities, or sequestration of carbon dioxide in reservoirs, or both; in any such case when for public use or when engaged in by a certified private operator, as defined in subdivision (4), subsection (j), section eleven-e of this article; transportation of coal and its derivatives and all mixtures and combinations thereof with other substances by pipeline; sleeping car or parlor car services; transmission of messages by telephone, telegraph or radio; generation and transmission of electrical energy by hydroelectric or other utilities for service to the public, whether directly or through a distributing utility; supplying water, gas or electricity, by municipalities or others; sewer systems servicing twenty-five or more persons or firms other than the owner of the sewer systems: Provided, That if a public utility intends to provide sewer service by an innovative, alternative method, as defined by the Federal Environmental Protection Agency, the innovative, alternative method is a public utility function and subject to the jurisdiction of the Public Service Commission regardless of the number of customers served by the innovative, alternative method; any public service district created under the provisions of article thirteen-a, chapter sixteen of this code; toll bridges, wharves, ferries; solid waste facilities; and any other public service: Provided, however, That natural gas producers who provide natural gas service to not more than twenty-five residential customers are exempt from the jurisdiction of the commission with regard to the provisions of such residential service: Provided further, That upon request of any of the customers of such natural gas producers, the commission may, upon good cause being shown, exercise such authority as the commission may deem appropriate over the operation, rates and charges of such producer and for such length of time as the commission may consider to be proper: And provided further, That the jurisdiction the commission may exercise over the rates and charges of municipally operated public utilities is limited to that authority granted the commission in section four-b of this article: And provided further, That the decision-making authority granted to the commission in sections four and four-a of this article shall, in respect to an application filed by a public service district, be delegated to a single hearing examiner appointed from the commission staff, which hearing examiner shall be authorized to carry out all decision-making duties assigned to the commission by said sections, and to issue orders having the full force and effect of orders of the commission.

(b) The commission may, upon application, waive its jurisdiction and allow a utility operating in an adjoining state to provide service in West Virginia when:

(1) An area of West Virginia cannot be practicably and economically served by a utility licensed to operate within the State of West Virginia;

(2) Said area can be provided with utility service by a utility which operates in a state adjoining West Virginia;

(3) The utility operating in the adjoining state is

regulated by a regulatory agency or commission of the adjoining state; and

(4) The number of customers to be served is not substantial. The rates the out-of-state utility charges West Virginia customers shall be the same as the rate the utility is duly authorized to charge in the adjoining jurisdiction. The commission, in the case of any such utility, may revoke its waiver of jurisdiction for good cause.

(c) Any other provisions of this chapter to the contrary notwithstanding:

(1) An owner or operator of an electric generating facility located or to be located in this state that has been designated as an exempt wholesale generator under applicable federal law, or will be so designated prior to commercial operation of the facility, and for which such facility the owner or operator holds a certificate of public convenience and necessity issued by the commission on or before the first day of July, two thousand three, shall be subject to subsections (e), (f), (g), (h), (i) and (j), section eleven-c of this article as if the certificate of public convenience and necessity for such facility were a siting certificate issued under said section and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility except for the making or constructing of a

material modification thereof as provided in subdivision (5) of this subsection.

(2) Any person, corporation or other entity that intends to construct or construct and operate an electric generating facility to be located in this state that has been designated as an exempt wholesale generator under applicable federal law, or will be so designated prior to commercial operation of the facility, and for which facility the owner or operator does not hold a certificate of public convenience and necessity issued by the commission on or before the first day of July, two thousand three, shall, prior to commencement of construction of the facility, obtain a siting certificate from the commission pursuant to the provisions of section eleven-c of this article in lieu of a certificate of public convenience and necessity pursuant to the provisions of section eleven of this article. An owner or operator of an electric generating facility as is described in this subdivision for which a siting certificate has been issued by the commission shall be subject to subsections (e), (f), (g), (h), (i) and (j), section eleven-c of this article and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility except for the making or constructing of a material modification thereof as provided in subdivision (5) of this subsection.

(3) An owner or operator of an electric generating facility located in this state that had not been designated as an exempt wholesale generator under applicable federal law prior to commercial operation of the facility, that generates electric energy solely for sale at retail outside this state or solely for sale at wholesale in accordance with any applicable federal law that preempts state law or solely for both such sales at retail and such sales at wholesale, and that had been constructed and had engaged in commercial operation on or before the first day of July, two thousand three, shall not be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility, regardless of whether such facility subsequent to its construction has been or will be designated as an exempt wholesale generator under applicable federal law: *Provided*, That such owner or operator shall be subject to subdivision (5) of this subsection if a material modification of such facility is made or constructed.

(4) Any person, corporation or other entity that intends to construct or construct and operate an electric generating facility to be located in this state that has not been or will not be designated as an exempt wholesale generator under applicable federal law prior to commercial operation of the facility, that will generate electric energy solely for sale at retail outside this state or solely for sale at wholesale in

accordance with any applicable federal law that preempts state law or solely for both such sales at retail and such sales at wholesale and that had not been constructed and had not been engaged in commercial operation on or before the first day of July, two thousand three, shall, prior to commencement of construction of the facility, obtain a siting certificate from the commission pursuant to the provisions of section eleven-c of this article in lieu of a certificate of public convenience and necessity pursuant to the provisions of section eleven of this article. An owner or operator of an electric generating facility as is described in this subdivision for which a siting certificate has been issued by the commission shall be subject to subsections (e), (f), (g), (h), (i) and (j), section eleven-c of this article and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility except for the making or constructing of a material modification thereof as provided in subdivision (5) of this subsection.

(5) An owner or operator of an electric generating facility described in this subsection shall, before making or constructing a material modification of the facility that is not within the terms of any certificate of public convenience and necessity or siting certificate previously issued for the facility or an earlier material modification thereof, obtain a

siting certificate for the modification from the commission pursuant to the provisions of section eleven-c of this article in lieu of a certificate of public convenience and necessity for the modification pursuant to the provisions of section eleven of this article and, except for the provisions of section eleven-c of this article, shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such modification.

(6) The commission shall consider an application for a certificate of public convenience and necessity filed pursuant to section eleven of this article to construct an electric generating facility described in this subsection or to make or construct a material modification of such electric generating facility as an application for a siting certificate pursuant to section eleven-c of this article if the application for the certificate of public convenience and necessity was filed with the commission prior to the first day of July, two thousand three, and if the commission has not issued a final order thereon as of that date.

(7) The limitations on the jurisdiction of the commission over, and on the applicability of the provisions of this chapter to, the owner or operator of an electric generating facility as imposed by, and described in this subsection, shall not be deemed to affect or limit the commission's jurisdiction over

contracts or arrangements between the owner or operator of such facility and any affiliated public utility subject to the provisions of this chapter.

(d) Any other provisions of this chapter to the contrary notwithstanding, any person, corporation, or other entity that has been determined by the commission to be a "certified private operator" as defined in subdivision (4), subsection (j), section eleven-e of this article, shall be subject to subsection (g), section eleven-e of this article and shall not otherwise be subject to the jurisdiction of the commission or to the provisions of this chapter with respect to such facility. The limitations on the jurisdiction of the commission over, and on the applicability of the provisions of this chapter to, a certified private operator, as imposed by and described in this subsection, shall not be deemed to affect or limit the commission's jurisdiction over contracts or arrangements between the certified private operator and any affiliated public utility subject to the provisions of this chapter.

§24-2-11e. Certificates of public convenience and necessity for carbon dioxide sequestration facilities or carbon dioxide transmission pipelines.

(a) Any public utility, person, or corporation that wishes to own or operate a carbon dioxide sequestration facility or carbon dioxide transmission pipeline as a public utility or a certified private operator shall obtain from the commission a certificate of public convenience and necessity approving the construction and proposed location of such facility prior to construction of such facility. Any prior operator wishing to own or operate such a facility as a public utility or a certified private operator shall be deemed to have a certificate of public convenience and necessity; provided, that any such prior operator shall be required, within ninety days of the effective date of this section, to apply for approval of the terms and conditions on which service or capacity of the facility will be provided, including whether the applicant seeks approval to provide service or capacity as a certified private operator.

(b) An application filed under subsection (a) of this section shall be in such form as the commission may prescribe and shall contain:

(1) A description, in such detail as the commission may prescribe, of the general location and type of carbon dioxide sequestration facility or carbon dioxide transmission pipeline which the applicant proposes to construct;

(2) A statement justifying the need for the facility;

(3) A description of the terms and conditions on which service or capacity of the facility will be provided, including whether the applicant proposes to provide service as a certified private operator; and

(4) Such other information as the applicant may deem relevant or the commission may require by rule.

(c) Upon the filing of such application, the applicant shall publish, in such form as the commission shall direct, as a Class I legal advertisement in compliance with the provisions of article three, chapter fifty-nine of this code, the publication area for such publication to be each county in which any portion of the proposed carbon dioxide sequestration facility or carbon dioxide transmission pipeline is to be constructed or located, a notice of the filing of such application. The commission may approve the application unless within fifteen days after completion of publication a written request for a hearing thereon has been received by the commission from a person or persons alleging that certification of the facility or its location is against the public interest. If such request be timely received and the commission determines that the issues raised in the protest cannot be effectively addressed without a hearing, the commission shall set the matter for hearing, and shall require the applicant to publish notice of the time and place of hearing in the same manner as is herein required for the publication of notice of the filing of the application.

(d) The commission shall approve the application if it shall find and determine that the construction and operation of the proposed carbon dioxide sequestration facility or carbon dioxide transmission pipeline (i) will economically, adequately and reliably contribute to meeting the present and anticipated requirements for the sequestration or transportation of carbon dioxide; and (ii) is otherwise convenient and necessary under the circumstances.

(e) The commission shall make any order approving the construction and operation of such a facility contingent upon the applicant's having obtained the necessary permits and authorizations, if any, from the department of environmental protection and any other state and federal agencies having jurisdiction. The commission's jurisdiction over the potential environmental impacts of such a facility shall be limited to requiring that the applicant obtain such permits and authorizations prior to commencing operation of the facility. The commission may include other reasonable conditions in its order approving the construction and operation of such a facility.

(f) The commission shall render its final decision on any application for a certificate of public convenience and necessity filed under the provisions of this section within three hundred days of the filing of the application. If no decision is rendered within such time period, the commission shall issue a certificate as applied for. The commission shall render its final decision on any application for approval filed pursuant to the second sentence of subsection (a) of this section, or any application by a private operator for authority to provide service or capacity pursuant to subsections (h) or (i) of this section, within one hundred fifty days of the filing of the application. If no decision is rendered within such time period, the commission shall issue an order granting the relief requested as applied for.

(g) The commission shall have continuing jurisdiction over any certified private operator, for the limited purposes of: (1) Considering future requests for modification of or amendments to the certificate; (2) considering and resolving complaints related to compliance with the material terms and conditions of the commission order issuing the certificate; and (3) enforcing the material terms and conditions of any commission order issuing or modifying the certificate.

(h) No private operator shall provide service or capacity from a carbon dioxide sequestration facility or carbon dioxide transmission pipeline to the public on an open-access, non-discriminatory basis until the commission has approved the terms and conditions upon which service or capacity of the facility will be provided and certified the private operator as a public utility with respect to the carbon dioxide sequestration facility or carbon dioxide transmission pipeline. In any application for such certification under this section, the commission may require such information about the private operator's operations and existing facilities as it may determine by rule. The commission may refuse to certify any such private operator as a public utility if it reasonably determines that the private operator willfully evaded the obligation to obtain a certificate of public convenience and necessity for such carbon dioxide sequestration facility or carbon dioxide transmission pipeline by initially electing to construct such facilities as a private operator and then seeking certification as a public utility with respect to such facilities.

(i) No private operator shall provide service or capacity from a carbon dioxide sequestration facility or carbon dioxide transmission pipeline as a certified private operator unless and until it has been certified as a certified private operator by the commission under this section. In any application for such certification under this section, the commission may require such information about the private operator’s operations and existing facilities as it may determine by rule. The commission may refuse to certify any such private operator as a certified private operator if it reasonably determines that the private operator willfully evaded the obligation to obtain a certificate of public convenience and necessity for such carbon dioxide sequestration facility or carbon dioxide transmission pipeline by initially electing to construct such facilities as a private operator and then seeking certification as a certified private operator with respect to such facilities.

(j) As used in this section, the following words and phrases shall have the following meanings:

(1) “Carbon dioxide sequestration facility” shall have the same meaning as defined in article eleven-a, chapter twenty-two of this code.

(2) “Carbon dioxide transmission pipeline” shall have the same meaning as defined in article eleven-a, chapter twenty-two of this code.

(3) “Certified private operator” means an entity that, pursuant to commission authority under this section, operates a carbon dioxide sequestration facility or carbon dioxide

transmission pipeline for the purpose of providing service or capacity at negotiated rates and charges to one or more identified persons approved by the commission, and which does not and does not intend to provide service or capacity from such facility on an open-access, non-discriminatory basis. Upon commission certification, a certified private operator may exercise the rights set forth in sections eight and nine, article eleven-a, chapter twenty-two of the code and section two, article one, chapter fifty-four of the code.

(4) "Prior operator" means any entity owning or operating a carbon dioxide sequestration facility or carbon dioxide transmission pipeline in existence and in operation on the effective date of this section to the extent that such facility has received all permits and approvals from the department of environmental protection required for the initial construction and operation of the facility.

(5) "Private operator" means an entity that operates a carbon dioxide sequestration facility or carbon dioxide transmission pipeline for the purpose of providing service or capacity at negotiated rates and charges to one or more identified persons, which does not and does not intend to provide service or capacity from such facility on an open-access, non-discriminatory basis, and which has not exercised

and does not intend to exercise any of the rights set forth in sections eight and nine, article eleven-a, chapter twenty-two of the code or section two, article one, chapter fifty-four of the code. A private operator is not a public utility and is not authorized to provide any service or capacity for public use.

(k) The commission may prescribe such rules as may be necessary to carry out the provisions of this section in accordance with the provisions of section seven, article one of this chapter.

CHAPTER 24B. GAS AND PIPELINE SAFETY.

ARTICLE 1. PURPOSE AND DEFINITIONS.

§ 24B-1-1. Purpose.

It is hereby declared to be the purpose and policy of the legislature in enacting this chapter to empower the public service commission of West Virginia, in addition to all other powers conferred and duties imposed upon it by law, to prescribe and enforce safety standards for pipeline facilities as hereinafter defined, and to regulate safety practices of persons engaged in the transportation of gas or hazardous liquids as hereinafter defined.

§ 24B-1-2. Definitions.

When used in this chapter:

(1) "Person" means any individual, firm, joint venture, partnership, corporation, association, state, municipality, cooperative association or joint-stock association, and includes any trustee, receiver, assignee or personal representative thereof;

(2) "Gas" means natural gas, carbon dioxide in a gaseous state, flammable gas or gas which is toxic or corrosive;

(3) "Transportation of gas" means the gathering, transmission or distribution of gas by pipeline or its storage;

(4) "Hazardous liquid" means:

(a) Petroleum or any petroleum product;

(b) Carbon dioxide in any physical state, and

(c) Any substance or material which is in liquid state (excluding liqu~~i~~efied natural gas) when transported by pipeline facilities and which, as determined by the commission, may pose an unreasonable risk to life or property when transported by pipeline facilities: Provided, That a hazardous liquid as herein defined shall not be construed so as to include or permit the regulation of any substance transported through pipeline or otherwise when used in the operation of coal mines, coal processing plants or coal slurry pipelines: Provided, however, That the commission shall not determine that any substance or material is a hazardous liquid under this section if the secretary has not determined that the substance or material is a hazardous liquid under regulations promulgated in accordance with Section 202(2) of the Hazardous Liquid Pipeline Safety Act of 1979;

(5) “Transportation of hazardous liquids” means the movement of hazardous liquids by pipeline, or their storage incidental to such movements; except that it shall not include any such movement through gathering lines in rural locations or on shore production, refining or manufacturing facilities or storage or in-plant piping systems associated with any of such facilities;

(6) “Pipeline facilities” means, without limitation, new and existing pipe, pipe rights-of-way and any equipment, facility, or building used in the transportation of gas or the treatment of gas during the course of transportation, or used in the transportation of hazardous liquid or the treatment of hazardous liquid during the course of transportation; but “rights-of-way” as used in this chapter does not authorize the commission to prescribe the location or routing of any pipeline facility;

(7) “Municipality” means a city, county or any other political subdivision of the state;

(8) “Interstate transmission facilities” means facilities used in the transportation of gas which are subject to the jurisdiction of the federal power commission under the act of Congress known as the Natural Gas Act;

(9) “Interstate pipeline facilities” means the pipeline facilities used in the transportation of hazardous liquids in interstate or foreign commerce;

(10) “Director” means the director of the gas pipeline safety section of the commission;

(11) “Commission” means the public service commission of West Virginia;

(12) “Secretary” means the United States of transportation;

(13) “Pipeline company” means a person engaged in the operation of pipeline facilities or the transportation of gas or hazardous liquids subject to the provisions of this chapter;

(14) “Act of 1968” means the act of Congress known as the Natural Gas Pipeline Safety Act of 1968; and

(15) “Act of 1979” means the act of Congress known as the “Hazardous Liquid Pipeline Safety Act of 1979.”

§ 24B-2-1. Jurisdiction.

The commission shall have power and authority to prescribe and enforce safety standards for pipeline facilities, and to regulate safety practices of persons engaged in the transportation of gas or hazardous liquids, to the extent permitted by the "Act of 1968" and the "Act of 1979" and any amendments thereto, and to regulate safety practices of persons engaged in the transportation of carbon dioxide, provided, however, that no such safety standards or safety practices shall be more stringent than any comparable federal requirements if any exist. Such standards may apply to the design, installation, inspection, testing, construction, extension, operation, replacement and maintenance of pipeline facilities. Standards affecting the design, installation, construction, initial inspection and initial testing shall not be applicable to pipeline facilities in existence on the date such standards are adopted. Whenever the commission shall find a particular facility to be hazardous to life or property, it shall be empowered to require the person operating such facility to take such steps necessary to remove such hazards. Such safety standards shall be practicable and designed to meet the need for pipeline safety. In prescribing such standards, the commission shall consider:

(a) Relevant available pipeline safety data;

(b) Whether such standards are appropriate for the particular type of pipeline transportation;

(c) The <u>reasonableness</u> of any proposed standards; and

(d) The extent to which such standards will contribute to public safety.

CHAPTER 54. EMINENT DOMAIN.

ARTICLE 1. RIGHT OF EMINENT DOMAIN.

§54-1-2. Public uses for which private property may be taken or damaged.

(a) The public uses for which private property may be taken or damaged are as follows:

(1) For the construction, maintenance and operation of railroad and traction lines (including extension, lateral and branch lines, spurs, switches and sidetracks), canals, public landings, wharves, bridges, public roads, streets, alleys, parks and other works of internal improvement, for the public use;

(2) For the construction and maintenance of telegraph, telephone, electric light, heat and power plants, systems, lines, transmission lines, conduits, stations (including branch, spur and service lines), when for public use;

(3) For constructing, maintaining and operating pipelines, plants, systems and storage facilities for manufacturing gas and for transporting petroleum oil, natural gas, manufactured gas, and all mixtures and combinations thereof, by means of pipes,

pressure stations or otherwise, (including the construction and operation of telephone and telegraph lines for the service of such systems and plants), and for underground storage areas and facilities, and the operation and maintenance thereof, for the injection, storage and removal of natural gas in subterranean oil and/or gas bearing stratum, which, as shown by previous exploration of the stratum sought to be condemned and within the limits of the reservoir proposed to be utilized for such purposes, has ceased to produce or has been proved to be nonproductive of oil and/or gas in substantial quantities, when for public use, the extent of the area to be acquired for such purpose to be determined by the court on the basis of reasonable need therefore. Nothing in this subsection shall be construed to interfere with the power of the state and its political subdivisions to enact and enforce ordinances and regulations deemed necessary to protect the lives and property of citizens from the effects of explosions of oil or gas;

(4) For carbon sequestration facilities and carbon dioxide transmission pipelines in accordance with the provisions of section eight, article eleven-a, chapter twenty-two of this code.