Carbon Sequestration Study

An analysis of geological and terrestrial carbon sequestration regulatory and policy issues

A Report to the 61st Legislature of the State of Montana
September 2008

Legislative Services Division

DRAFT

Energy and Telecommunications Interim Committee
2007-08 Interim

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This report is a summary of the work of the Energy and Telecommunications Interim Committee. This summary is specific to the ETIC's study of carbon sequestration. Throughout the interim, the ETIC reviewed volumes of information on the topic. Special thanks are extended to the Montana Board of Oil and Gas Conservation, Department of Environmental Quality, and Big Sky Carbon Sequestration Partnership, who were instrumental in the preparation of this report. A complete catalog of information, including written minutes and, in some cases, audio minutes, is available on the ETIC website:

www.leg.mt.gov/etic

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Appendices

(In an effort to save paper, a link to the appendices referenced in the report is included below. The final report will include hard copies of the information.)

Figures and Tables

Introduction

With the first meeting of the 2007-08 Energy and Telecommunications Interim Committee (ETIC) in July 2007, ETIC members ventured into what is widely referred to as the "carbon conundrum". Although not the subject of an assigned study bill, members reached a consensus that a significant portion of ETIC time for the interim would be spent considering a potential policy or regulatory framework as it relates to carbon sequestration in Montana.

Members adopted a work plan requiring a study of specific aspects of sequestration to determine where modifications to existing law or additions to the law merited consideration. To reach its goal in October 2007, the ETIC traveled to Colstrip to visit the Colstrip Steam Electric Station--a power plant fueled by coal that generates about 2,100 megawatts of electricity. Members toured the plant and received information on retrofitting existing plants in Montana to operate in a potentially carbon-constrained environment and learned about the feasibility of sequestration overall in Montana.

In late 2007, the Environmental Protection Agency (EPA) announced its plans to develop rules to ensure that geological carbon sequestration wells are constructed and managed in a manner that protects underground sources of drinking water. The draft rules were released in July 2008, but those rules aren't expected to be final until late 2010 or 2011. Without the final rules and with questions remaining about the role of the federal government, the ETIC was limited in its ability to completely address the regulatory issues raised by carbon sequestration. In an April 2008 letter to the Montana Board of Oil and Gas Conservation, which was shared with the ETIC, the EPA made it very clear that the agency will provide overall regulatory guidance on the issue.

> EPA recognizes several state legislatures have enacted new laws aimed at accelerating efforts to contain carbon emissions within their jurisdictions and that some states may be working to publish their own GS [geologic sequestration] program regulations this year. It is important for state program managers to understand that, under the Safe Drinking Water Act, state requirements must be at least as stringent as the federal requirements in order to receive EPA approval. Thus, if regulations are issued prior to EPA regulations, it may eventually be necessary to revise state UIC [underground injection control] program requirements in order to obtain EPA approval.

The complete letter is included in **Appendix A**.

Throughout the ETIC's study, the public was invited to weigh in on the subject. During the interim, the ETIC heard from some of the state's and nation's experts on the subject of sequestration.

Based on the work plan adopted by the ETIC in 2007, members reviewed seven specific issues:

✔Feasibility of geological and terrestrial carbon sequestration in Montana and the characteristics of areas of the state where carbon could be sequestered.

✔Methods and technologies for the geological and terrestrial sequestration of carbon.

✔Findings and recommendations of the Montana Climate Change Advisory Committee (MCCAC) related to carbon sequestration.

✔An inventory of sources and volumes of carbon produced in Montana.

✔Existing state and federal regulations governing carbon sequestration.

✔Liability issues related to sequestration and legal issues related to ownership rights.

✔Costs and benefits of carbon sequestration.

After completing the interim study tasks as outlined in **Appendix B**, ETIC members reached an agreement to issue a report with findings on the subject of sequestration, as well as to develop two bill drafts for ETIC discussion. The ETIC, however, did not ultimately vote to pursue those bill drafts.

The first bill draft that was discussed was LC4002. It established the surface owner as the owner of pore space used for the storage of carbon dioxide or other substances. The bill protected existing oil and gas statutes and affirmed the dominance of the mineral estate. Based on public comment that the ETIC received, members voted 6 to 1 to not pursue LC4002. The bill draft and the public comment that the ETIC received are included in **Appendix C**.

A second ETIC bill draft, LC4003, was a study bill. ETIC members proposed a study bill limited to the subjects of jurisdiction, liability, and cost. If approved, the bill would have charged the ETIC with completing a study, more indepth than that which is included in this report, during the 2009-10 interim. Rather than pursue a study bill, the ETIC voted 6 to 1 to pursue a study resolution on the subject of carbon sequestration.

Members noted that it will be important for Montana lawmakers to closely monitor activity on the federal level in this arena and be prepared during the 2011 Montana Legislature to address the issues of a complete regulatory framework to guide the injection and storage of carbon dioxide. The study resolution, which requests a more indepth study of geological sequestration, is included in **Appendix D.**

This report is based on the most up-to-date information available. It is intended to outline the processes and information used by the ETIC in reaching its conclusions.

ETIC Carbon Sequestration Findings

✔Feasibility of geological and terrestrial carbon sequestration in Montana and the characteristics of areas of the state where carbon could be sequestered.

Finding: The Big Sky Carbon Sequestration Partnership, based in Bozeman, is examining the feasibility of both geological and terrestrial sequestration in Montana.

Finding: The Big Sky Carbon Sequestration Partnership has found that CO_2 sequestration storage potential in depleted oil and gas fields in the region is about 1 billion metric tons of CO_2. Saline aquifers present about 200 billion metric tons of CO_2 storage potential. Substantial characterization work of these formations and sinks needs to be completed.

Finding: The National Carbon Offset Coalition includes seven Montana nonprofit corporations that help landowners and other public and private organizations participate in market-based conservation programs to offset greenhouse gas emissions.

Finding: Through terrestrial sequestration, major agricultural states can potentially play a role in offsetting greenhouse gas emissions by storing carbon in soils.

✔Methods and technologies for the geological and terrestrial sequestration of carbon.

Finding: As identified by the Big Sky Carbon Sequestration Partnership, the region including Montana has a range of geological sites for CO_2 storage, including depleted oil reservoirs, unminable coal seams, saline aquifers, and basalt formations. The type of geological sites used for sequestration will be determined in part by the state's geography, and at this time, it is unknown how many such sites may be useful for sequestration specific to Montana. Basalt formations, for example, are primarily found in Washington, Oregon, and Idaho.

Finding: Terrestrial carbon sequestration can include cropping and tilling practices, grazing practices, methane offsets, and forestry and afforestation. The Big Sky Carbon Sequestration Partnership is engaged in projects to quantify and verify some types of terrestrial sequestration opportunities.

✔Findings and recommendations of the Montana Climate Change Advisory Committee (MCCAC) related to carbon sequestration.

Finding: The MCCAC offered 54 policy recommendations for reducing greenhouse gas emissions in the state to1990 levels by 2020 and in November 2007 released the Montana Climate Change Action Plan outlining each of the recommendations.

Finding: During the 2007-08 interim, the Environmental Quality Council conducted an indepth review of the recommendations, pursuing aspects through draft legislation and reports.

✔An inventory of sources and volumes of carbon produced in Montana.

Finding: Activities in Montana account for about 37 million metric tons of carbon dioxide equivalent emissions or 0.6% of all greenhouse gas emissions in the United States. Electricity use, transportation, and agriculture are the principal emissions sources.

Finding: An Energy Information Administration report (based on 2004 data and released in 2008) shows 35.1 million metric tons of CO_2 being emitted in Montana, 19.1 million metric tons resulting from electric power production.

✔Existing state and federal regulations governing carbon sequestration.

Finding: There is a limited framework of existing statutes regarding carbon sequestration. However, many states are working through policy discussions that deal with regulatory frameworks related to CO_2 storage. Wyoming, in 2007, was the first state to adopt an indepth regulatory scheme.

Finding: Two bills were passed and approved during Montana's 2007 legislative and special sessions that address the carbon issue--House Bill No. 25 (HB 25), approved during the regular 2007 session, and House Bill No. 3 (HB 3), approved during the 2007 special session. Both bills address, to some degree, the issue of carbon sequestration, particularly as it applies to power generation and equipment.

Finding: The Interstate Oil and Gas Compact Commission (IOGCC) in 2007 drafted a report that includes a series of recommendations on a CO_2 framework. The report analyzes technical, policy, and regulatory issues related to the storage of carbon dioxide in the subsurface, including oil and natural gas fields, saline formations, and coal beds.

Finding: In October 2007, the EPA announced plans to establish rules for geological sequestration and in July 2008 released draft rules. The EPA currently uses the Class V experimental technology well permits for pilot CO_2 sequestration projects. The new regulations will ensure that a permitting system for CO_2 injection is consistent with what is now under the Safe Drinking Water Act of 1974. The Safe Drinking Water Act is established under the Underground Injection Control (UIC) program. The EPA has proposed draft regulatory changes to the UIC program that were not final at the time of this report's completion.

Finding: The Energy Independence and Security Act of 2007 appears to give the EPA explicit authority under the Safe Drinking Water Act to regulate the injection of carbon dioxide. The outcome of additional federal legislation on sequestration remained uncertain at the close of the 2007-08 interim.

✔Liability issues related to sequestration and legal issues related to ownership rights.

Finding: Because there are a number of unknowns about carbon sequestration and because jurisdictional questions remain, the issues of liability will likely evolve as additional regulatory issues are determined.

Finding: The question of liability may be addressed differently, depending on whether the stored carbon is considered a pollutant or a commodity. Potential responsible parties for carbon sequestration could include: storage site landowners, injectors, operators, transporters, generators, lenders, or contractors. Transfer of liability to government also has been discussed.

Finding: In looking at other states for guidance in this area, there are limited examples. Wyoming has not addressed the liability issue, but has created a task force to further examine related matters. Other states continue to examine the issue. Texas, for example, approved legislation accepting liability for CO_2 stored underground in FutureGen projects.

Finding: The Wyoming Legislature established that pore space is owned by the surface owner, and the ETIC discussed similar draft legislation but did not opt to pursue it.

✔Costs and benefits of carbon sequestration.

Finding: The costs of carbon capture and sequestration are uncertain and may be determined in part by successful commercial demonstrations of carbon capture and storage, by carbon market prices, and by state and federal decisions regulating carbon emissions.

Finding: There are a variety of risks associated with sequestration, including leaks to the surface, which in large amounts could be dangerous to human life, the potential for potable aquifer contamination, and the possible risk of induced seismicity because of movement of displaced fluids.

Finding: Benefits range from reducing greenhouse gas emissions to providing new markets for the agriculture industry. The National Energy and Technology Laboratory notes that sequestration works toward implementation of national energy policy goals to develop new technologies and supports international collaborations to reduce greenhouse gas emissions and intensity. Sequestration can provide potential economic benefits in oil and gas fields via enhanced oil recovery.

Feasibility

As constraints on carbon emissions are increasingly discussed, many experts consider carbon capture and sequestration a viable option in the energy industry's near future.

About 50% of the electricity generated in the U.S. is from coal, according to federal Energy Information Administration 2005 annual statistics. At the same time, one 500 megawatt coal-fired power plant produces about 3 million tons of carbon dioxide each year, according to a Massachusetts Institute of Technology study of coal.[1]

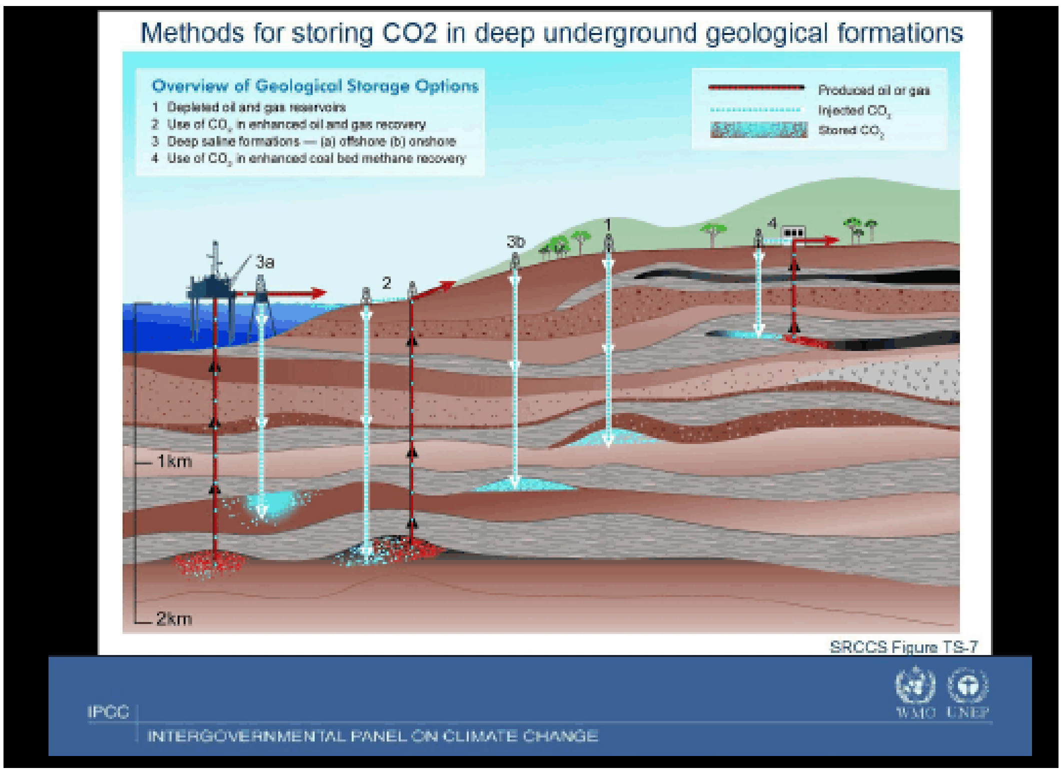

Figure 1
Source: Intergovernmental Panel on Climate Change

Montana is endowed with a wealth of coal, reserves totaling 119.2 billion tons, roughly 25% of the United State's total.[2]

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[1] *The Future of Coal: Options for a Carbon-Constrained World*, An Interdisciplinary MIT Study, 2007, Executive Summary, page IX.

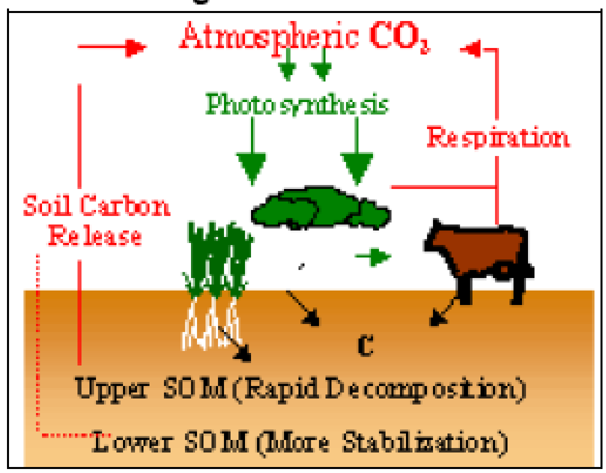
[2] http://montanacoalcouncil.com/facts_figures.html

There are also ongoing efforts to mine Montana coal and use it to generate electricity and even refine it into a liquid fuel source. The MIT study, which was published in 2007, declares carbon capture and sequestration "the critical enabling technology to help reduce CO_2 emissions significantly while also allowing coal to meet the world's pressing energy needs".[3]

As illustrated in **Figure 1**, geological carbon sequestration is the process of trapping carbon dioxide after it is created from the production, processing, and burning of coal, gas, and oil and injecting it underground.

Terrestrial sequestration is the process through which carbon dioxide from the atmosphere is absorbed by trees, crops, or plants through photosynthesis and stored as carbon in biomass, like tree branches or soils.[4] Forests and croplands are often called carbon "sinks" because they sequester more carbon than the amount of carbon released during forestry or agricultural activities. **Figure 2** shows this process.

Figure 2. Carbon Sequestration in Agricultural Soils



Source: USGS, "Carbon Sequestration in Soils," at [http://edcintl.cr.usgs.gov/carbonoverview.html].
SOM = Soil organic matter

Simply put, carbon capture means that the gas doesn't enter the atmosphere. By capturing carbon dioxide at industrial plants, carbon can be kept out of the atmosphere. In terms of geological sequestration, there is an opportunity to store carbon deep under the earth's surface. Worldwide estimates of carbon storage capacity range from 2 trillion to 10 trillion tons of CO_2.[5] In 2005, worldwide carbon emissions reached 28 billion tons, according to the U.S. Department of Energy's Energy Information Administration.[6]

In Montana, storage capacity and potential storage locations are being studied by the Big Sky Carbon Sequestration Partnership. It has examined areas of Montana where geological sequestration is likely. This information is included in **Figure 3**. Another map is available online

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[3] *The Future of Coal: Options for a Carbon-Constrained World*, An Interdisciplinary MIT Study, 2007, Executive Summary, page X.

[4] U.S. Environmental Protection Agency Carbon Sequestration in Agriculture and Forestry, http://www.epa.gov/sequestration/faq.html.

[5] http://news-service.stanford.edu/news/2007/june13/carbon-061307.html

[6] http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls

under "publications" and "staff reports" at www.leg.mt.gov/etic. The Big Sky Carbon Sequestration Partnership, led by Montana State University, is one of the U.S. Department of Energy's seven regional partnerships. Researchers are developing a framework to address carbon dioxide emissions and are working with stakeholders to create a "vision for a new, sustainable energy future."[7]

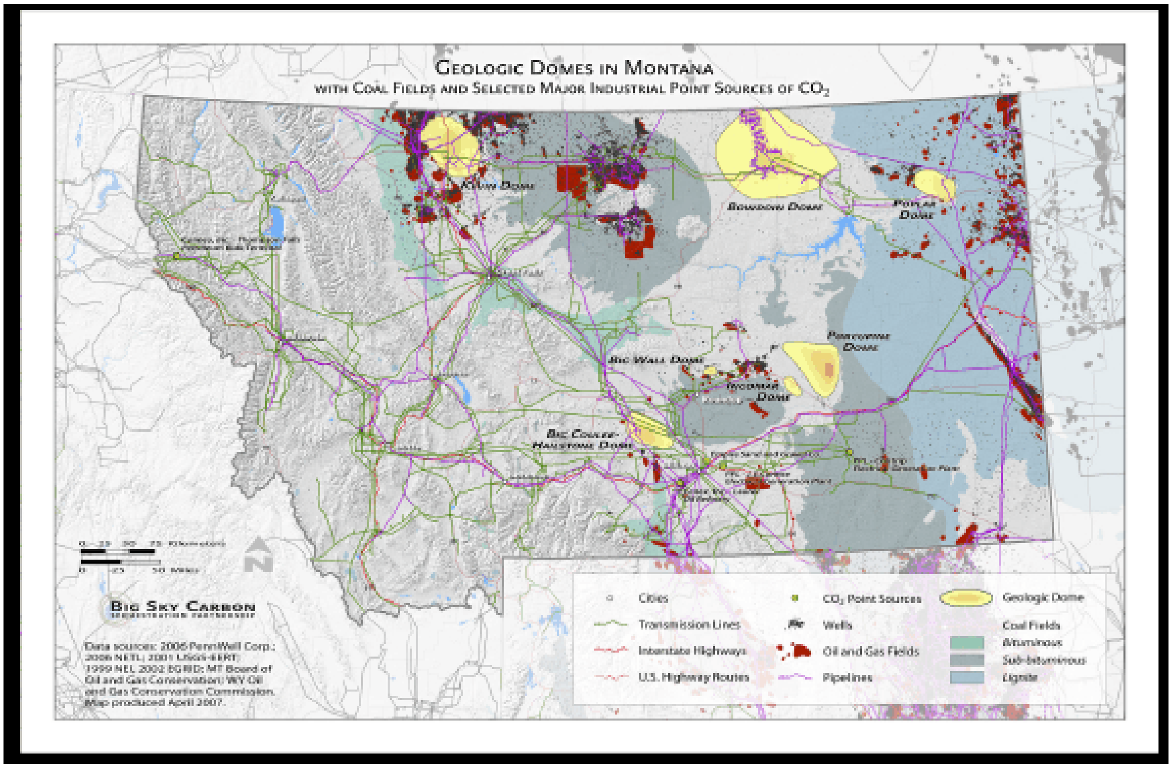

Figure 3
Source: Big Sky Carbon Sequestration Partnership

Terrestrial sequestration offers another opportunity. The National Carbon Offset Coalition includes seven Montana nonprofit corporations that help landowners and other public and private organizations participate in market-based conservation programs to offset greenhouse gas emissions. The Coalition has developed a handbook to help landowners plan carbon sequestration efforts and document those efforts, making them marketable.[8] Technical consulting is provided in part by the Chicago Climate Exchange, the world's first marketplace for integrating emissions reductions with emissions trading and offsets.

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[7]http://www.bigskyco2.org/

[8]http://www.ncoc.us/

Methods and Technologies

The Department of Energy has formed seven regional partnerships that are testing the feasibility of sequestration. The Big Sky Carbon Sequestration Partnership is working to identify and verify the most promising technologies in Montana, Wyoming, Idaho, South Dakota, Washington, and Oregon. Researchers rely on existing technologies from the fields of engineering, geology, chemistry, biology, geographic information systems (GIS), and economics to develop novel approaches for both geological and terrestrial carbon storage in the region. The Partnership engages in cutting-edge carbon sequestration research and development; economic and regulatory analyses; public education and outreach; and regional demonstration projects to deploy new technologies.[9] The Partnership also is examining the infrastructure that will be needed to deploy commercial scale carbon sequestration projects. "This supporting infrastructure includes a geographic information system [GIS]-based economic and risk assessment tool to help determine optimal energy development strategies, regulatory and permitting approaches, and enhanced public understanding and acceptance."[10]

Geological Carbon Sequestration

To capture carbon, CO_2 is extracted from waste gases created during fossil fuel combustion. It is then injected underground and stored. Many different types of capture and sequestration are under review by a variety of researchers in the world. In geological sequestration, the carbon dioxide is stored for long terms underground. As identified by the Big Sky Carbon Sequestration Partnership, the region including Montana has a range of geological sites for CO_2 storage, including depleted oil reservoirs, unminable coal seams, saline aquifers, and basalt formations. The Partnership has found that CO_2 sequestration storage potential in depleted oil and gas fields in the region is about 1 billion metric tons of CO_2. Saline aquifers in the region present about 200 billion metric tons of CO_2 storage potential. A site where injection occurs must have sufficient permeability and porosity to accept the gas. The formation needs to be at sufficient depth to maintain the CO_2 in a super critical state through hydrostatic pressure. Ideally, there also are several caprocks to contain the CO_2. Potable water sources above also must be protected.

Enhanced oil recovery

Since the early 70s, engineers have been putting carbon dioxide into oil reservoirs to increase oil production. Enhanced oil recovery (EOR), in most cases currently, is the process of using alternate flows of water and carbon dioxide that are pumped into an oil reservoir to push additional oil to production wells. There also are other methods to apply CO_2 flooding. An oversimplified explanation is that the carbon dioxide makes the oil expand so that it flows more easily. In the U.S., there are currently 70 CO_2 injection projects, injecting about 35 million tons a

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[9] Information provided in comments by Big Sky Carbon Sequestration Partnership.

[10] Ibid.

year of CO_2 for EOR.[11]

Carbon sequestration for EOR is currently utilized at a coal gasification plant in Beulah, North Dakota. A 204-mile carbon dioxide pipeline from the plant to the Weyburn oil field in Saskatchewan, Canada, transports about 5,000 tons of carbon dioxide a day to the oil fields, where 130 million barrels of oil are expected to be produced during a 20-year project. The project results in an annual 1 million tons of carbon dioxide being sequestered rather than sent into the atmosphere.

In Wyoming, the Enhanced Oil Recovery Institute estimates that about 20 trillion cubic feet of CO_2 could be sequestered and used in Wyoming's oil fields. Rancher Energy Corporation is beginning work on a CO_2 EOR project in the South Glenrock and Big Muddy fields east of Casper, Wyoming.

The Enhanced Oil Recovery Institute estimates that as much as 60% of original oil reserves can remain unproduced after conventional recovery methods are used.[12] The Big Sky Carbon Sequestration Project also is working in Wyoming and looking at EOR.

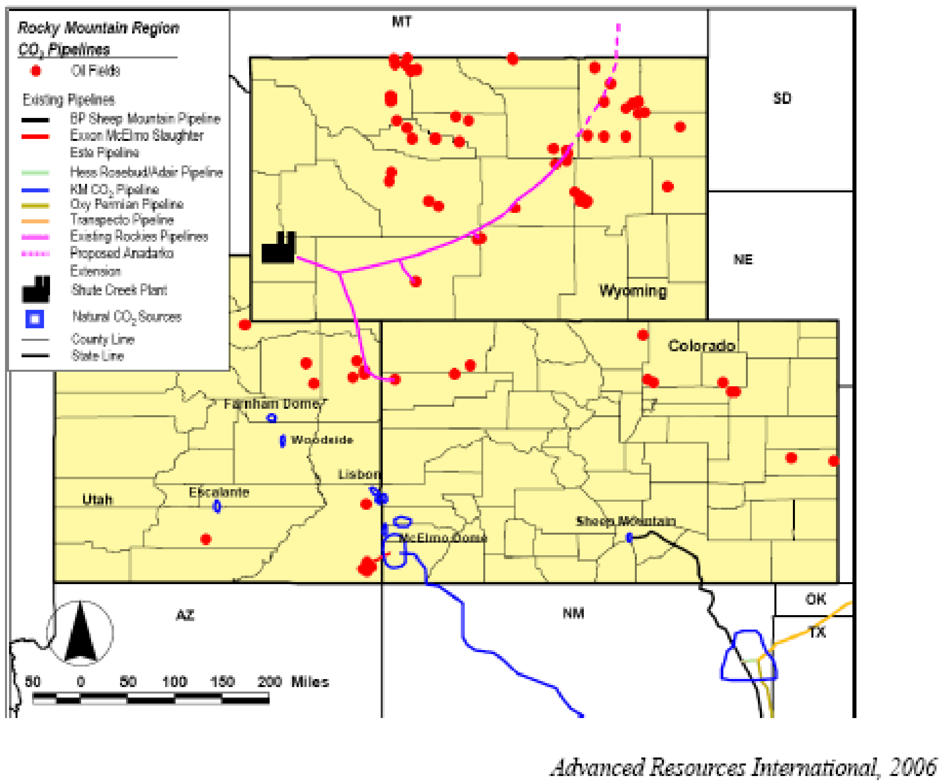

Figure 4
Source: Wyoming Pipeline Authority, 2007

Wyoming industry officials are working to develop a wider network of CO_2 pipelines.[13] Oil producers in the

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[11] "No Time Like the Present: NRDC's Response to MIT's 'Future of Coal' Report", David Hawkins and George Peridas, 2007, page 4.

[12] http://eori.gg.uwyo.edu/

[13] *Billings Gazette*, "CO2 seen as key", by Dustin Bleizeffer, June 27, 2007.

southern Powder River Basin have said that they would be interested in purchasing CO_2, if pipelines are developed to link areas to the north and east. **Figure 4** outlines the CO_2 pipeline structure under review in Wyoming. Most CO_2 that is currently used for EOR in the United States comes from natural carbon reservoirs, not carbon recovered from power generation.

Saline aquifers

In Montana, several saline aquifers, or large geological domes, are being studied as potential long-term storage sites. Potential storage sites have been identified in several key areas of Montana. The Big Sky Carbon Sequestration Partnership is examining these areas and looking at the potential to permanently store carbon dioxide.

The Kevin Dome in northcentral Montana has been identified as a key area. Its dome structure has the potential to serve as a commercial CO_2 reservoir. Carbon could be removed or piped from the site during periods of high demand for EOR. It also serves as a natural CO_2 reservoir. At the Kevin Dome, carbon would be sequestered 3,500 feet to 5,000 feet underground. The dome has the potential to store 1 to 2 gigatons (a gigaton is equivalent to a billion metric tons) of CO_2. **Figure 5** includes a more indepth look at that dome.

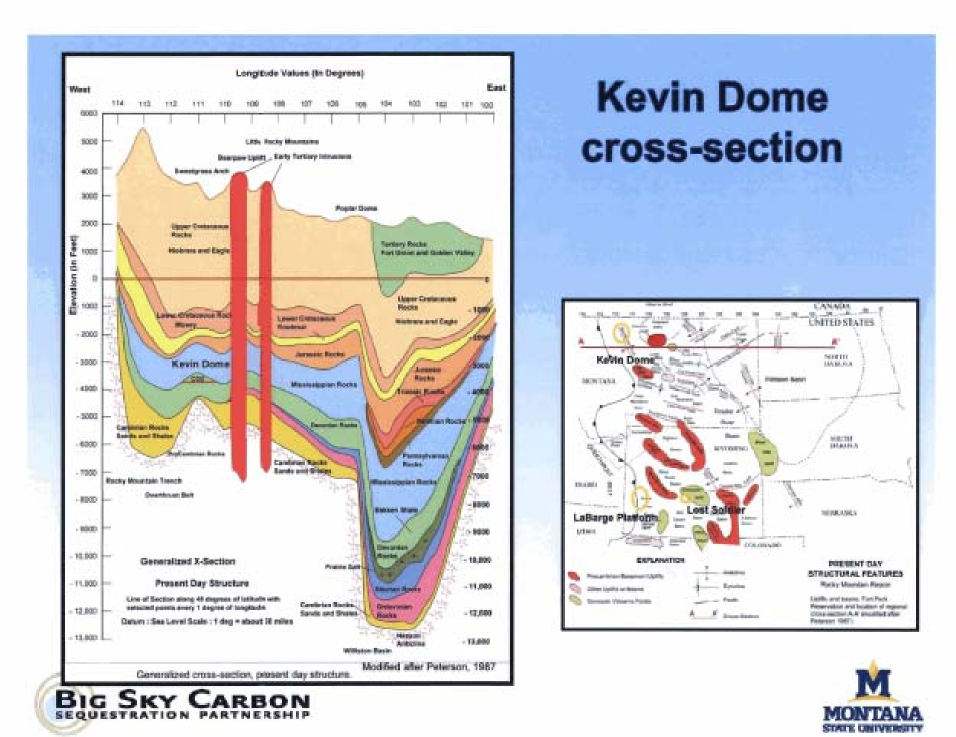

Figure 5
Source: Big Sky Carbon Sequestration Partnership

At a large-scale sequestration project in Norway, oil and gas company Statoil is injecting carbon dioxide from its Sleipner West natural gas production facility into an aquifer beneath the North Sea. The project has been underway since 1996, and Statoil reports that seismic surveys show that volumes exceeding the limits of detection are not observed to have moved from the target storage formation. Statoil has put 1 million tons of carbon dioxide into the aquifer annually.[14]

Unmineable coal seams

Coal beds adsorb CO_2, and injected CO_2 can displace methane, which can be recovered. The injection of carbon dioxide into coal seams can then enhance recovery of coal bed methane. If a bed is used for sequestration, however, the injected coal cannot be mined in the future.[15] The Midwest Regional Carbon Sequestration Partnership is studying the feasibility of such storage. Some tests have shown that coal will adsorb about twice as much carbon dioxide as methane, which gives it the potential to displace methane and remain underground. Swelling also may accompany the adsorption. Limited field tests have demonstrated CO_2 recovery of coal bed methane, and more study is needed to optimize such a process.[16]

Basalt formations

Within the region being studied by the Big Sky Carbon Sequestration Partnership, volcanic basalt covers 85,000 square miles, and preliminary calculations show that the basalt could store more than 100 billion tons of carbon dioxide. Researchers are testing how well the volcanic rocks below the Columbia and Snake River Plains store carbon dioxide. Researchers will inject 3,000 tons of carbon dioxide about 3,000 feet into Washington State's Columbia River basalt formation in Eastern Washington. The scientists will then track the way that the gas moves underground and watch for leaks. "Basalt formations may offer a unique geological medium for long-term, secure carbon sequestration."[17]

<u>Terrestrial Carbon Sequestration</u>

In the United States, between 6% and 8% of all greenhouse gas emissions are attributed to agricultural activities. Agricultural and forestry practices also can reduce greenhouse gases by maintaining existing carbon storage in trees and soils. A 2007 EPA report showed that carbon sequestration in agricultural soils in 2005 was about 30 million metric tons of CO_2.[18] Forested

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[14] http://www.geotimes.org/mar03/feature_demonstrating.html

[15] *Assessing Carbon Sequestration Potential for "Unmineable" Coal Beds in Eastern Kentucky,* Greb, Weisenfluh, and Eble, Kentucky Geological Survey, University of Kentucky.

[16] http://www.netl.doe.gov/publications/factsheets/project/Proj440.pdf

[17] *Big Sky Regional Carbon Sequestration Partnership -- Validation Phase*, U.S. Department of Energy, Office of Fossil Energy National Energy Technology Laboratory, February 2007.

[18] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005,* April 2007. http://epa.gov/climatechange/emissions/usinventoryreport.html

lands and trees are credited with about 95% of all estimated carbon uptake in the United States, which includes tree planting activities and forest land remaining forest land.[19]

The role of agricultural and forest lands in sequestering carbon is complex, but is increasingly gaining attention as carbon cap-and-trade programs take shape. Carbon sequestration units (CSUs) can be used to represent an amount of organic carbon sequestered in soil or forests that is equivalent to the removal of one metric ton of CO_2 from the atmosphere. The CSUs can then be packaged into portfolios by groups like the National Carbon Offset Coalition based in Butte and offered for sale on private markets, like the Chicago Climate Exchange. Farmers and ranchers sign up their carbon offsets, and organizations serve as a type of broker. As an example set by the National Carbon Offset Coalition, in Eastern Montana, 28 counties qualify for exchange soil carbon offsets for conservation tillage. Producers can earn carbon credits at a rate of 0.32 metric tons an acre each year during the nonfallow year. Credits can be earned between 2006 and 2010 on registered acres. Carbon exchange rates for rangeland are earned at a rate of 0.12 to 0.24 metric tons an acre each year of CO_2 sequestered on eligible land. In July 2009, about 100 landowners received checks totaling about $550,000 for enrolling land in carbon credit programs, according to the Montana Farmers Union.[20]

In northcentral Montana, there are at least two projects underway to monitor and verify terrestrial carbon offsets. One project is in its sixth year and is comparing tilled and direct seed systems, including fallow-wheat and lentil-wheat cropping rotations, at six different farms. The locations will be studied and used to generate a regional carbon sequestration rate for tilled systems. A second project is examining soil properties to determine surface soil carbon and to predict soil carbon at depth. Montana State University and the Big Sky Carbon Sequestration Partnership are involved in these as well as additional terrestrial projects.

Cropland

Untilled cropland holds about a third of a ton of carbon an acre, according to National Carbon Offset Coalition figures.[21] Mulch farming and conservation tillage are agricultural processes that return biomass to the soil. Crop rotation, agroforestry systems, and application of biosolids to the soil also increase soil organic carbon. For credit with the National Carbon Offset Coalition, for example, low-residue crops like soybeans, peas, and lentils are eligible if a cover crop is included in the rotation. Pilot projects have shown that changes in cropping practices, like a change from conventional to conservation tillage, can sequester carbon.

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[19]CRS Report for Congress, *Climate Change: The Role of the U.S. Agriculture Sector*, Renee Johnson, updated December 14, 2007.

[20] "Carbon credits: $550,000 to Montana farmers", *Billings Gazette*, Associated Press, July 30, 2008.

[21] Estimates of sequestration rates provided by the National Carbon Offset Coalition.

Rangeland
Grazing management that employs sustainable stocking rates, rotational grazing, and seasonal use on nondegraded rangelands are considered practices eligible to be integrated into a carbon trading system. Other practices that could apply include restoration of degraded rangelands through sustainable stocking rates, rotational grazing, and seasonable use grazing. Improved rangeland management generally reduces water usage and increases productivity on grasslands. The Big Sky Carbon Sequestration Partnership is continuing with a study started in 1982 that focuses on carbon sequestration management practices on rangeland. Researchers have collected 320 soil samples, showing that grazing intensity has a significant influence on soil organic carbon.[22]

Methane Offsets
The estimated 100 million cattle in the U.S. emit about 5.5 million metric tons of methane each year, around 20% of methane emissions in the nation, according to the EPA.[23] Agricultural methane collection and combustion systems can offset greenhouse gases. Agricultural systems, including covered lagoons, anaerobic digesters, or complete-mix and plug-flow digesters, are all eligible projects. There are multiple other guidelines in this particular area. "The most promising approach for reducing methane emissions from U.S. livestock is by improving the productivity and efficiency of livestock production."[24]

Forestry
Sequestering and retaining increased amounts of carbon from the atmosphere in forests can vary depending on the types of trees. In Idaho, the Nez Perce planted ponderosa pines, Douglas fir, and larch saplings among old-growth stands on land that had been cleared in the past for farming. Estimates there show an acre of pine forest capturing and holding one to two metric tons of CO_2 each year. The Nez Perce tribe has 4,000 acres that it has planted with trees in multiple projects on the reservation.[25] Beetle infestations and drought are among the necessary considerations in forestry-related sequestration. In 2001, for example, the Salish Kootenai sold sequestration rights on 250 acres to a company in London. Drought conditions killed the trees, which all had to be replanted. The Big Sky Carbon Sequestration Partnership is engaged in a forestry field test in the Northern Rockies to quantify sequestration potential in forests.

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[22] *Big Sky Regional Carbon Sequestration Partnership -- Validation Phase*, U.S. Department of Energy, Office of Fossil Energy National Energy Technology Laboratory, April 2008.

[23]http://www.epa.gov/rlep/faq.html

[24]Ibid.

[25] "Sale of Carbon Credits Helping Land-Rich, but Cash-Poor, Tribes", *New York Times*, Jim Robbins, May 8, 2007.

Montana Climate Change Advisory Committee

In December 2005, Governor Brian Schweitzer asked Montana's Department of Environmental Quality (DEQ) to form a Montana Climate Change Advisory Committee (MCCAC) to study the impact of climate change in Montana.

The MCCAC was made up of 18 members representing industry, environment, local and tribal governments, transportation, and agriculture.[26] The DEQ contracted with the Center for Climate Strategies to develop a comprehensive inventory and forecast of greenhouse gas emissions in Montana from 1990 to 2020. The Center for Climate Strategies, a nonprofit organization that works with groups like the MCCAC to design and implement policies that address climate mitigation, facilitated development of Montana's plan.

The Center for Climate Strategies also worked with the MCCAC to develop possible policy options for reducing greenhouse gas emissions. Five technical working groups were organized to advise the full MCCAC and provide technical analysis. The five groups included agriculture, forestry, and waste; energy supply; residential, commercial, and industrial; transportation and land use; and cross-cutting issues. The energy supply technical working group, for example, examined greenhouse gas reductions and the cost-effectiveness of environmental portfolio standards, renewable energy incentives, and market-based carbon issues, like a carbon tax.

The MCCAC voted on individual policy recommendations that were presented to the Governor in November 2007 for possible implementation. The MCCAC reached a consensus on 54 policy recommendations for reducing greenhouse gas emissions in the state to1990 levels by 2020 and released the Montana Climate Change Action Plan outlining each of the recommendations.[27]

The MCCAC reached agreement on recommendations based on those options in early July 2007. The energy supply recommendations are included in **Appendix E**.

Emissions in Montana

The Center for Climate Strategies prepared a greenhouse gas inventory under a contract with the DEQ. The report was prepared to assist the MCCAC. The inventory includes carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Aerosol emissions, including "black carbon" from fossil fuel combustion, also were included. Emissions

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[26] A full list of the Montana Climate Change Advisory Committee is available at http://www.mtclimatechange.us/ewebeditpro/items/O127F11863.pdf.

[27] The Montana Climate Change Action Plan can be viewed at http://www.mtclimatechange.us/CCAC.cfm.

inventoried in the report do not solely include carbon dioxide but instead include a common metric, CO_2 equivalent.

Montana's gross greenhouse gas emissions are rising at about the same rate as the nation's on the whole.[28] Montana's emissions per capita are higher, primarily because of the state's fossil fuel production industry, agricultural industry, large distances for transportation, and low population density. Forestry activities are estimated to be net sinks for emissions, and agricultural soils are estimated to sequester additional gases.

The inventory shows that activities in Montana account for about 37 million metric tons of carbon dioxide equivalent emissions or 0.6% of all greenhouse gas emissions in the United States. Electricity use, transportation, and agriculture are the principal emissions sources. The combustion of fossil fuels for generating electricity used in Montana combined with the transportation sector account for about 50% of the gross greenhouse gas emissions in the state.[29] Agricultural emissions are primarily methane and nitrous oxide from manure management, fertilizer use, and livestock. Other types of emissions are from households, large industry, commercial business, wastewater treatment operations, and the oil and gas industry. A more detailed look at emissions in Montana is included in **Figure 6**.

The report also includes emissions from electricity production, which are discussed in this report. Historically, Montana has produced about twice as much electricity as was consumed in the state. As an example, in 2000, Montana exported 41% of the electricity that it produced, according to the inventory. That same year, emissions associated with electricity consumption were 9.5 million metric tons of CO_2 equivalent--significantly lower than emissions associated with electricity production, which were 17.1 million metric tons of CO_2 equivalent.[30] These numbers also may require additional scrutiny because much of the energy exported in Montana is generated by hydroelectric facilities.

Under what is referred to as a "business as usual" approach, Montana's greenhouse gas emissions are expected to increase, climbing to 42 million metric tons by 2020 or 30% above 1990 levels, according to the inventory. Transportation is expected to be the largest contributor to future emissions, followed by the electric sector. The estimates are based on a scenario in which no

[28]*Montana GHG Inventory and Reference Case Projections 1990-2020*, Center for Climate Strategies, principal authors: Alison Bailie, Stephen Roe, Holly Lindquist, and Alison Jamison, September 2007, page 4.

[29]Ibid. page 5.

[30]Ibid.

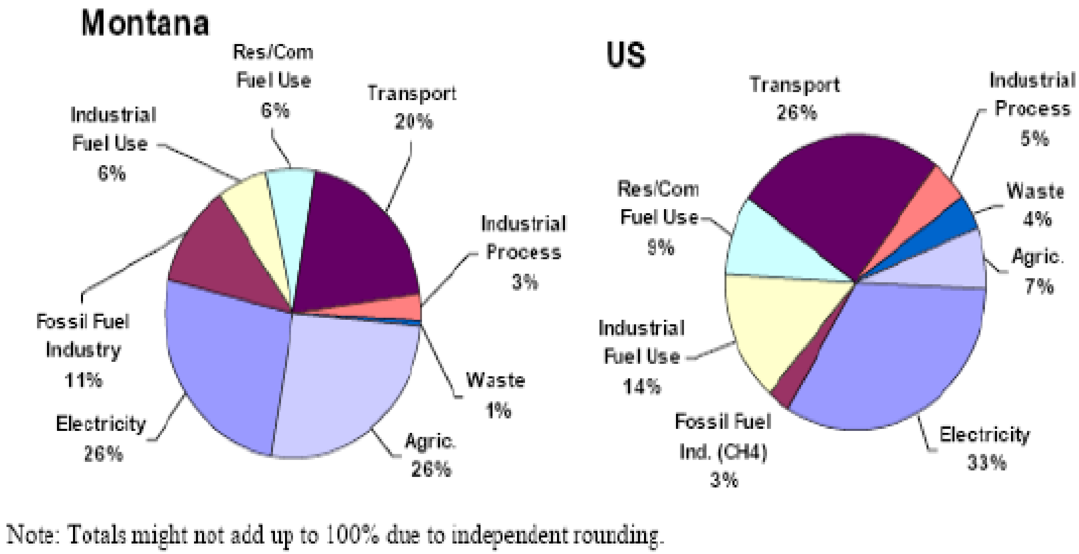

Figure 6 Gross GHG emissions by sector, 2000, Montana and US
Source: *Montana GHG Inventory and Reference Case Projections 1990-2020*

coal-to-liquids facilities are operating in the state. The inventory also contemplated a "high fossil fuel production" scenario with two coal-to-liquids plants being developed. That scenario assumes that additional electricity transmission lines are developed between Montana and the southern United States and from Montana to Alberta, Canada. The additional capacity on those lines is assumed to be used by a mix of 65% circulating fluidized bed coal electricity production and 35% wind energy production. The scenarios also show natural gas production tripling over current levels and refining capacity increasing. Under those assumptions, emissions reach 52 million metric tons in 2020.[31] In 2007, coal accounted for 64% of electricity generation in Montana, and hydropower accounted for 34%.[32] Total greenhouse gas emissions from the four largest Montana plants totaled 18 million metric tons of $C0_2$-equivalent in 2004. Colstrip, the largest plant, accounts for 82% of Montana's greenhouse gas emissions from power plants.[33]

A 2005 Energy Information Administration (EIA) report uses 1990 to 2004 data to calculate state-level emissions from fuel categories, including coal, natural gas, and petroleum products. The EIA report (released in 2008) shows 35.1 million metric tons of CO_2 being emitted in

[31]Ibid. page 10.

[32]"The Electricity Law Handbook: A Montanan's Guide to Understanding Electricity Law", revised 2008, page 44.

[33]*Montana GHG Inventory and Reference Case Projections 1990-2020*, Center for Climate Strategies, principal authors: Alison Bailie, Stephen Roe, Holly Lindquist, and Alison Jamison, September 2007, page 32.

Montana, 19.1 million metric tons resulting from electric power.[34] Between 1990 and 2006, CO_2 emissions from the electric power sector have grown by about 29%, according to the report.[35] The most recent report shows energy-related carbon dioxide emissions grew by 1.6% in 2007.[36]

The EPA also has published an Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006. Energy-related activities, primarily fossil fuel combustion, accounted for the majority of U.S. CO_2 emissions between 1990 and 2006. In 2006, about 83% of the energy consumed in the United States was produced through the combustion of fossil fuels.[37] "The process of generating electricity is the single largest source of emissions in the United States, representing 39 percent of [total CO_2] emissions from all sources across the country in 2005."[38]

In general, federal tracking of greenhouse gas emissions is based on a voluntary national registry. Power plants subject to the 1990 Clean Air Act acid rain program, however, must report certain emissions, including carbon dioxide, to the EPA. In Montana, those plants include: Rocky Mountain Power, PPL Corette, PPL Colstrip, Montana-Dakota Utilities Lewis and Clark Station, and Montana-Dakota Utilities Glendive Station. Based on the EPA Clean Air Markets reporting shown in **Table 1,** those plants emitted about 22.4 million tons of CO_2 in 2007.

Table 1

EPA Clean Air Markets: CO_2 Tons			
Facility	**2007**	**2006**	**2005**
Colstrip	19,382,297	18,240,485	19,219,042
Glendive	62,645	30,824	37,715
Hardin	950,823	3,293	(not in operation)
Corette	1,522,727	1,528,248	1,268,273
Lewis and Clark	501,257	503,041	441,038

Source: EPA: Clean Air Data and Markets. http://camddataandmaps.epa.gov

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[34]http://www.eia.doe.gov/environment.html

[35]http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html

[36]http://www.eia.doe.gov/oiaf/1605/flash/flash.html

[37] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, ES-12, Executive Summary, April 2008. http://www.epa.gov/climatechange/emissions/downloads/08_ES.pdf.

[38]http://www.epa.gov/climatechange/fq/emissions.html

Efforts to Report Emissions

Greenhouse gas emissions aren't currently regulated by the federal government. However, in 2007, the U.S. Supreme Court ruled that the EPA has failed to use its authority to regulate carbon in automobile exhaust as a pollutant. In the absence of federal laws on the subject of greenhouse gas emissions, states are forming individual and regional tracking and reductions programs.

Regional climate registries are developing across the nation. Montana is a member of the Western Climate Initiative that also includes Arizona, California, New Mexico, Oregon, Utah, and Washington. The Canadian provinces of British Columbia, Quebec, and Manitoba also joined. States will identify, evaluate, and implement ways to reduce greenhouse gas emissions. The initiative requires an overall regional goal to reduce emissions.[39]

The Regional Greenhouse Gas Initiative (RGGI) includes Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, and Vermont. Starting in 2009, carbon emissions from power plants in those states will be capped at current levels--about 121 million metric tons annually. The cap remains until 2015 when the states then incrementally reduce emissions by 10% by 2019. It will be the first mandatory cap and trade program for emissions in the U.S.[40]

Thirty-one states, including Montana, are also part of the Climate Registry, a national initiative to track greenhouse gas emissions. The registry, a nonprofit organization, will be used to track, measure, verify, and publicly report greenhouse gases. State agencies, corporations, and educational institutions are invited to report emissions under the voluntary program. Some states also have mandatory reporting requirements.

Nearly 30 states have completed or are in the process of completing climate change action plans.[41] Another 17 states have set statewide greenhouse gas emissions targets. A summary of climate change related activities in the region is included in **Appendix F**.

At the local level, the mayors of Billings, Missoula, and Bozeman signed on to the U.S. Mayors Climate Protection Agreement, committing to reduce emissions in their cities to 7% below 1990 levels by 2012.[42]

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[39] http://www.westernclimateinitiative.org/

[40] *Model Rule and Amended Memorandum of Understanding,* Regional Greenhouse Gas Initiative.

[41] "Climate Change 101: State Action", Pew Center on Global Climate Change, page 7. http://www.pewclimate.org/docUploads/101_States.pdf.

[42] www.usmayors.org/climateprotection/

Regulatory Efforts

There is a limited framework of existing legislation regarding carbon sequestration. However, many states are working through policy discussions that deal with regulatory frameworks related to CO_2 storage and sequestration. Washington state has one of the most comprehensive frameworks to date. A report prepared by the National Conference of State Legislatures outlining state activities related to sequestration is included in **Appendix G**. A supplement on activities in Wyoming, New Mexico, Washington, and Oklahoma also is included.

The IOGCC drafted a report titled "Carbon Capture and Storage: A Regulatory Framework for States", which includes a series of recommendations on a CO_2 framework. The report analyzes technical, policy, and regulatory issues related to storage of carbon dioxide in the subsurface, including oil and natural gas fields, saline formations, and coal beds. Efforts to draft the report were funded by the Department of Energy and the National Energy Technology Lab. The report analyzes regulatory frameworks for capture, transportation, injection, and postinjection storage. "Establishment of a carbon capture and geological sequestration regulatory scheme in any particular jurisdiction will require an assessment for each component of the technical issues and a review of the existing regulatory framework."[43] The report resulted in model rules and statutes being adopted by the IOGCC in September 2007. An analysis of the IOGCC model statutes prepared at the request of the ETIC is included in **Appendix H**.

Storage of CO_2 raises the question of whether CO_2 captured, for example, at a power plant is considered a pollutant or a commodity and what agencies need to be involved in monitoring and regulation of the gas. In many states, including Montana, storage of natural gas, liquefied natural gas, and petroleum reserves is currently regulated with permitting, siting, and monitoring regulations in place. "Conceptually a societal decision has been made that the benefit of storage in terms of energy security and improved ability to meet demand outweighs the potential for negative impacts."[44] The benefits and risks of such storage as it relates to CO_2 are being discussed in many forums. The underground storage of natural gas in Montana is outlined in Title 82, chapter 10, of the Montana Code Annotated.

Underground fluid injection is currently regulated through the EPA's UIC program. The program is part of the Safe Drinking Water Act established to protect underground water resources from contamination. Based on that system, there are five classes of wells for waste injection. Class II permits currently are issued for wells that are used for energy production, like EOR. The IOGCC report recommends that CO_2 injection wells be a subclass of Class II permits or be permitted under an entirely new federal classification. Pilot sequestration projects are currently regulated under Class V. As mentioned earlier in this report, the EPA has released draft rules discussing carbon sequestration. The draft rules would create a new class, Class VI permits, for geological carbon sequestration. It is unclear at this time if a state, like Montana, would be able to attain

[43] *Carbon Capture and Storage: A Regulatory Framework for States,* Interstate Oil and Gas Compact Commission, 2005, page 2.

[44] *Regulatory Barriers for Carbon Capture, Storage and Sequestration,* Sarah M. Forbes, National Energy Technology Laboratory, November 2002.

primacy over these new wells. A brief overview of the draft rules released by the EPA in July 2008 is included in **Appendix I**.

In Montana, the EPA enforces permitting for Classes I and III through V. The Montana Board of Oil and Gas Conservation enforces Class II. The state program is required to address environmental health and safety and to protect water from contamination by the injection or storage of natural gas.

Pipeline movement of CO_2 is currently regulated under Title 49 of the Code of Federal Regulations Part 195 (49 CFR 195) by the U.S. Department of Transportation Office of Pipeline Safety. Depending on location and size, a new pipeline proposed in Montana that is regulated under the Natural Gas Pipeline Safety Act of 1968 or the Hazardous Liquid Pipeline Safety Act of 1979 may need permitting through the DEQ, the Public Service Commission, and multiple other sources.

Incentives

To date, 14 states have enacted or are in the process of enacting legislation with some form of financial incentive for "clean coal technologies".[45] Those incentives range from streamlined permitting in Colorado for certain technologies to tax credits for coal gasification facilities in Kansas. Kentucky, for example, requires its state Public Service Commission to approve various long-term contracts by utilities when the projects are for synfuel plants that use coal. Wyoming offers a sales and use tax exemption for equipment purchased to develop coal gasification or liquefaction facilities.[46]

Several states have formed carbon sequestration advisory boards to provide guidelines and calculate the costs of offsetting emissions. In general, these advisory boards focus on terrestrial sequestration in agriculture and forestry ecosystems. Nebraska, Wyoming, and Idaho have advisory committees.[47] In 2002, Idaho created a carbon sequestration advisory committee. The Idaho Soil Conservation Commission provides leadership for the group, and a Carbon Sequestration Assessment Fund was developed.[48] The Wyoming Carbon Sequestration Advisory Committee was created through state legislation under the Wyoming Carbon Storage Law.[49]

Montana also has approved legislation that provides incentives for new technologies. A review of those incentives is included below.

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[45] National Conference of State Legislatures, Quarterly Review of Energy Policy and Activities in the State Legislatures, March 2007.

[46] Wyoming State Statutes 39-15-105 (2006).

[47] *Carbon Sequestration Role in State and Local Actions*, Department of Energy/NETL, Melissa Chan and Sarah Forbes, January 2005, page 5.

[48] Idaho Law 22-5101 (2002).

[49] http://www.wyomingcarbon.org/

Advancing Research

Montana legislators have over the years created a variety of study and research organizations, many aimed at economic development or focused specifically on agricultural commodities. The Board of Research and Commercialization Technology (MBRCT) is created in 2-15-1819, MCA. It is attached to the Department of Commerce. Each year the MBRCT collects applications and awards research grants. In 2007, the MBRCT awarded 23 grants totaling $3.2 million in funding. The purpose of the research and commercialization special revenue account in 90-3-1002 and 90-3-1003, MCA, is to:

> (a) provide a predictable and stable source of funding for research and commercialization projects conducted in the state that demonstrates to both private and public sources, including federal research granting agencies, that Montana recognizes the important contributions that research and commercialization endeavors offer to the state's basic industries.
>
> (b) expand and strengthen research efforts for the state's basic industries to increase their economic impact on the state's economy;
>
> (c) expand research efforts into areas beyond the scope of the state's basic industries to diversify and strengthen the state's economic security through the creation of technology-based operations and long-term quality jobs; and
>
> (d) pay costs of administering of this part pursuant to 90-3-1003. (90-3-1001, MCA)

The 2007 Legislature expanded opportunities for awarding such grants. If applications are received, at least 30% of the account funds approved for research and commercialization projects must be directed toward projects that enhance clean coal research and development or renewable resource research and development, based on the amended law.

In April 2008, Montana State University in Bozeman, which includes the Big Sky Carbon Sequestration Partnership, received about $157,000 from the MBRCT to assist in funding its geological sequestration efforts at the Kevin Dome in northcentral Montana.

The current definition of "universal system benefits programs" includes public programs for "research and development programs related to energy conservation and renewables", as well as "market transformation designed to encourage competitive markets for public purpose programs".

Past Legislatures also have worked in this area. In 1991, the Clean Coal Technology program was approved. House Bill No. 701 created a clean coal demonstration account in the coal tax trust fund. It put $5 million a year for 6 years into the fund, and when a company applied for a loan, the next Legislature made a decision whether or not to award the loan. The Department of Natural Resources and Conservation (DNRC) designated legitimate projects. Projects had to show "efficiency in electricity generation and reduced pollutant emissions compared to current coal burning methods". Loans were made to projects that showed matching funds on a 4:1 ratio. Loans could not be made for early stage planning or preliminary research.

The bill was directed toward a clean coal demonstration project proposed at the Corette Plant in Billings. The project was aimed at reducing emissions and integrating a coal cleaning process. The $400 million project was to be paid primarily with a federal grant from the Department of Energy.

During a 1993 special session, the Legislature repealed the program. Elimination of the program was part of the DNRC's 10% budget reduction, which was mandated by the regular 1993 session. The project in Billings also did not receive federal funding, and the DNRC reported a lack of interest in the program.

2007 Montana Legislation

During the 2007 legislative session, members of the Montana Legislature were introduced to a multitude of greenhouse gas and climate change-related bills. Carbon and related greenhouse gases were the topic of a variety of bills considered during the session. **Appendix J** includes the list. A Montana Climate Change Caucus led by Rep. Mike Phillips also took shape. Rep. Sue Dickenson requested that the Legislative Council assign a study of climate change, House Joint Resolution No. 60, which would have coordinated efforts with the MCCAC. That resolution was tabled. Rep. Alan Olson introduced a study bill, House Bill No. 828, which outlined a study of carbon sequestration issues in Montana. That bill also died in the process.

Two bills were passed and approved that address the carbon issue--HB 25, approved during the regular 2007 session, and HB 3, approved during the 2007 special session.

The Electric Utility Industry Generation Reintegration Act (HB 25) includes a carbon sequestration component. Until the state or federal government adopts uniformly applicable standards, HB 25 prohibits the Public Service Commission from approving acquisitions or leases of facilities or equipment used to generate electricity that is primarily fueled by coal unless a minimum of 50% of the CO_2 produced by the facility is captured and sequestered. Natural gas plants also must include cost-effective carbon offsets. The bill applies only to electric generating units constructed after January 1, 2007. The Public Service Commission is responsible for rulemaking related to carbon dioxide as stipulated in HB 25. By March 31, 2008, the Public Service Commission was directed to adopt rules to implement the cost-effective carbon offsets required at new facilities fueled by natural or synthetic gas. Those rules are included in **Appendix K**.

HB 3, as it relates to topics covered in this report, provides tax incentives for energy generation facilities that emit less carbon than conventional technologies. Incentives also are provided for equipment that sequesters carbon. Based on the legislation, numerous types of facilities constructed after May 2007, including integrated gasification combined cycle (IGCC) plants that sequester carbon dioxide and natural gas combined cycle plants that offset a portion of the carbon dioxide produced through carbon credit offsets, are eligible for tax abatements. The percentage of carbon dioxide to be sequestered must be based on technology that is "practically obtainable as determined" by the DEQ, but not less than 65%.

Eligible facilities will be assessed at 50% of their taxable value for a period not to exceed 19 years, which includes up to 4 years for construction and 15 years of operation. IGCC facilities that apply for an air quality permit after 2014 are not qualified. Coal-to-liquids plants and other gasification plants that sequester carbon are not subject to the deadline.

An IGCC facility would be considered class fourteen property and taxed at 3% of its market value, as opposed to 6% currently. New equipment at existing power plants used to capture and to prepare for the transport of carbon dioxide also is considered class fourteen property. HB 3 gives permanent property tax rate reductions from 12% to 3% of market value for new investments in carbon sequestration pipelines. Coal-to-liquids facilities with carbon sequestration also are taxed at 3% of market value.

Liability and Ownership Rights

Liability and Oversight

The question of liability may be addressed differently, depending on whether stored carbon is considered a pollutant or a commodity. Potential responsible parties for carbon sequestration could include: storage site landowners, injectors, operators, transporters, generators, lenders, or contractors. In addressing the liability question, first party insurance, direct government regulation combined with insurance, payments out of the tax system, trust accounts, liability caps, or systems of guaranteed benefits could be considered. "The degree of stringency varies across our regulatory analogs from a fairly unregulated approach in natural gas to a more structured approach in hazardous waste."[50]

Because there are a number of unknowns about carbon sequestration and because carbon would be stored for long periods of time, transfer of liability to the public sector also has been discussed in some states. In Texas, the Railroad Commission, acting on behalf of the state, acquires title to carbon dioxide captured by clean coal projects, specifically the proposed FutureGen project. The transfer of title, however, does not relieve the owner of liability for the generation of carbon dioxide performed before the CO_2 is captured.

By limiting potential liabilities, some believe sequestration projects will be encouraged. Some state governments are examining options for accepting liability for a limited number of projects or for a limited time--for example, accepting liability for the first deep saline project or for the first 5 years of sequestration. With liability transferred to the state, some public entities are discussing a fund managed by the state based on a fee assessed per volume sequestered. Others are discussing options for CO_2 injectors to purchase insurance in the private market.

Liability for damages to property for oil and gas development in Montana is outlined in 82-10-505, MCA:

[50] "Towards a Long-Term Liability Framework for Geologic Carbon Sequestration", M.A. de Figueiredo, D.M. Reiner, and H.J. Herzog, May 2003.

> The oil and gas developer or operator is responsible for all damages to real or personal property resulting from the lack of ordinary care by the oil and gas developer or operator. The oil and gas developer or operator is responsible for damages to real or personal property caused by drilling operations and production.

The Board of Oil and Gas Conservation also oversees the requirements that oil and gas developers in Montana must follow as outlined in 82-11-123, MCA. Developers are required to furnish a reasonable bond, and an oil and gas production damage mitigation account also exists and is used to assist in mitigation costs as determined by the Board. The account historically has been used as an agency match for grant applications for reclamation projects and as an emergency cleanup fund. The state assumes responsibility over time for orphaned wells. "The transportation, injection and storage of carbon dioxide has been commonplace in oil and gas production for decades, and the liability associated with operational impacts is managed today."[51]

In Montana, a "hazardous waste", as defined in 75-10-403, MCA, is a waste or combination of wastes that:

> because of its quantity, concentration, or physical, chemical, or infectious characteristics, may:
> (i) cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or
> (ii) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed.

Hazardous waste injection wells are not regulated under the Montana hazardous waste program, but are subject to requirements under a federal hazardous waste program. Class I wells are monitored by the EPA and are considered technologically sophisticated wells "that inject large volumes of hazardous or non-hazardous wastes into deep, isolated rock formations that are separated from the lower most [Underground Safe Drinking Water] by layers of impermeable clay and rock".[52]

The EPA has used the Class V experimental technology well permits for pilot CO_2 sequestration projects. "This guidance and the Class V experimental technology well permits will bridge the gap between pilot and commercial-scale projects. . . . On the basis of the data collected, the Agency may consider developing regulations tailored specifically for CO_2 injection."[53] As noted

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[51] Ibid.

[52] http://www.gwpc.org/e-library/e-library_documents/e-library_documents_general/classi.htm

[53] "Using the Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects", UIC Program Guidance (UICPG # 83), EPA, March 2007, page 3.

earlier in this report, the EPA in October 2007 announced its intentions to develop rules governing injection controls for carbon dioxide and in July 2008 released new, draft rules.

In Montana, water quality standards also merit review in relation to sequestration. The Montana water quality laws in Title 75, chapter 5, MCA, provide guidance for the "prevention, abatement, and control of water pollution". The Board of Environmental Review is assigned the responsibility of establishing criteria to determine whether activities, or a class of activities, result in nonsignificant changes in water quality. Nonsignificant activities are enumerated in 75-5-317, MCA. It also is notable that in Montana, beyond stated exemptions, it is unlawful to construct, modify, or operate a disposal system that discharges into any state waters without a DEQ permit. "State waters" include surface and ground water.

Surface and Subsurface Rights

Property with underground pore space and the potential injection of CO_2 into that pore space raises several legal questions related to ownership. Mineral owners, surface owners, lessees of minerals, and the owners of production are all part of the potential equation. The IOGCC looked at three models for guidance: injection of CO_2 for EOR, natural gas storage in geological formations, and injection of acid gas into geological formations. The task force concluded that the law recognizes an ownership interest in subsurface pore space.
ETIC staff attorney Todd Everts prepared a legal opinion on the topic of surface and subsurface rights in Montana to assist ETIC members in a discussion about ownership issues. That opinion is included in **Appendix L**. The ETIC also discussed this issue indepth in its review of LC4002, although it did not pursue the draft.

Economics

Costs

The costs of carbon capture and sequestration are uncertain and may be determined in part by successful commercial demonstrations of carbon capture and storage, by carbon market prices, and by state and federal decisions regulating carbon emissions. "Successful implementation of CCS will inevitably add cost for coal combustion and conversion", according to MIT's "Future of Coal" report. In that report, researchers examined both a high-price trajectory and a low-price trajectory. In the high-price scenario, researchers looked at $25 a ton for CO_2 in 2015 with increases of 4% a year thereafter. At $25 a ton, capture and storage technology approaches a level that makes it more economically feasible.[54] In the low-price scenario, researchers used $7 a ton for CO_2 in 2010, with a 5% increase thereafter. Using the low-price scenario, carbon capture and sequestration becomes more economical about 25 years later than under the high-price scenario, according to the report. Carbon markets in the U.S. over the last few years have put the price of 100 metric tons of CO_2 equivalent between $3 and $10 a ton. In June 2008 carbon was at

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[54]*The Future of Coal: Options for a Carbon-Constrained World*, An Interdisciplinary MIT Study, 2007, Executive Summary, page XI.

a price of about $5.45 a ton. Much discussion about pricing continues. Chevron, for example, considers the MIT prices to be extremely optimistic, specifically the capture costs.

Based on information included in **Table 2**, capture increases the cost of electricity production (not the price of electricity paid by customers) by 35%-70% for a natural gas combined cycle plant, 40%-85% for a supercritical pulverized coal plant, and 20%-55% for an IGCC plant. "The costs of retrofitting existing power plants with CO_2 capture have not been extensively studied."[55] The feasibility and costs of capture are site specific and depend on the size, age, and efficiency of a plant, availability of space for capture and compression equipment, and type of fuel burned.

Table 2

Economic Issues			
Power Plant System	Natural Gas Combine Cycle (US$/kWh)	Pulverized Coal (US$/kWh)	Integrated Gasification Combined Cycle (US$/kWh)
Without capture (reference plant)	0.03-0.05	0.04-0.05	0.04-0.06
With capture and geological storage	0.04-0.08	0.06-0.10	0.05-0.09
With capture and enhanced oil recovery	0.04-0.07	0.05-0.08	0.04-0.07

Source: Intergovernmental Panel on Climate Change,
http://www.mnp.nl/ipcc/pages_media/SRCCS-final/ccsspm.pdf

PPL Montana, which is an operator at the Colstrip Steam Electric Station, noted in its presentations before the ETIC in 2007 that it believes that the energy penalty for carbon capture at a coal fired power plant could be as high as 30%. The company has some preliminary estimates of the costs of retrofitting Colstrip for carbon capture. Company officials, however, stress that the information is preliminary and does not indicate any specific plan of action. As background, Colstrip has an O&M budget of about $97.6 million, with capital at about $52.6 million. Technology reviewed by PPL assumes 90% capture with carbon at $4 a ton. It has looked at three options for retrofitting as outlined in **Table 3**. Chevron notes that the costs for the chilled ammonia process remain uncertain.

Table 3

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[55] "Carbon Dioxide Capture and Storage: Summary for policymakers and technical summary", Intergovernmental Panel on Climate Change, Executive Summary.

PPL Montana Estimates for Carbon Capture			
Technology	**Capital Cost**	**O&M**	**CO_2 Removal Cost Per Ton**
Amine Scrubber Process	$430 million	$900 million (includes a 30% energy penalty or about 625 MW of energy being used for the capture process)	$53
Chilled Ammonia Process (capture carbon in flue gas)	$430 million	$650 million (includes a 9% energy penalty or about 189 MW of energy being used for the capture process)	$39
Biological Capture Process (use of algae and photosynthesis) This assumes 40% capture as opposed to 90% and includes an infrastructure with about 26 square miles of algae.	$1.7 billion	$417 million (revenue = $750 million based on biodiesel)	Revenue per ton = $95

Source: PPL Montana

The costs associated with compressing and transporting carbon also must be considered. Pipeline costs are another consideration. The Wyoming Pipeline Authority has examined potential numbers for a CO_2 pipeline infrastructure. Some CO_2 pipelines are already operating in Wyoming, and the Authority looked at a CO_2 grid with about 480 miles of new line. In the Wyoming analysis, the Authority reviewed a 10-to 30-year initial contract life, a fixed monthly fee based on units of contract capacity that is paid whether capacity is used or not, and usage fees. It has examined those costs in terms of the varying contract lengths. A CO_2 pipeline could cost as much as $52,000 to $57,000 per inch mile, with the compression borne by the suppliers. The Wyoming analysis relies on a debt/equity ratio of 70/30 and debt at 7%.[56] With the expected high costs of infrastructure, the credit worthiness of shippers is critical, according to the analysis.

The Pipeline Authority also notes the differences between CO_2 expansions and natural gas expansions. Jurisdiction for CO_2 pipelines is in question. There is no existing grid, accepted rate

[56] Presentation by Brian Jeffries, executive director Wyoming Pipeline Authority, Big Sky Carbon Sequestration Partnership Annual Forum, August 23, 2007, Bozeman, Mont.

design, market depth, standard contract, or forward market, and there is uncertainty about creditworthy supporters. Questions about funding for such an expansion also are noteworthy. Sources that have been discussed include states, the federal government, EOR producer coalitions, utility buyers of generation output, and CO_2 producers, according to the Authority. A more indepth review of pipeline costs is included in **Table 4**.

Table 4

Rate Matrix -- 540,000 Mcf/d System			
Contract term (yrs)	Levelized rate per Mcf of capacity	Annual fixed fees on a 50,000 Mcf/d contract	Life of contract fixed fees on a 50,000 Mcf/d contract
10	$0.44	$8 MM	$80 MM
15	$0.37	$6.8 MM	$101 MM
20	$0.34	$6.2 MM	$124 MM
30	$0.31	$5.7 MM	$172 MM

Source: Wyoming Pipeline Authority

To date, a lot more work in analyzing the costs of terrestrial sequestration has been completed. For now, economic analysis related to geological sequestration is focused on sequestration for EOR and sequestration in deep saline aquifers. Research in this area is ongoing.

Risks

Carbon dioxide is a natural part of the atmosphere; however, large concentrations can be a direct risk to humans. In the spring of 2006, three ski patrol members suffocated on Mammoth Mountain in California afer being overcome by toxic fumes. Carbon dioxide and other gases naturally vent from volcanic fissures on the mountain, and the patrol members fell into a snow cave and died from a lack of oxygen, which was displaced by carbon dioxide.[57] In 1986, residents of a village in the African nation of Cameroon were killed when the water in a volcanic lake overturned and released a massive amount of carbon dioxide.

Other risks to humans include the potential for potable aquifer contamination and the possible risk of induced seismicity because of movement of displaced fluids. When CO_2 is injected, it can react with saltwater in underground formations and make them more acidic. That water can dissolve minerals, like heavy metals, which can migrate with the water through the underground storage area. "Scientists currently use monitoring to track the migration of plumes in groundwater. Sequestration sites will be selected because they are isolated from ground water by

[57] "Three die from toxic gases at California ski resort", by Sonya Geis, *Washington Post*, April 8, 2006.

layers of dense rock."[58] Some scientists believe that dissolved carbon dioxide plumes would not seep into ground water and that monitoring could show plume migration. Pumping could be used to prevent contamination if a plume was nearing ground water, according to some researchers.

Other mitigation strategies also are possible, and a risk assessment would likely identify potential risks and mitigation plans for dealing with such risks. Seismic activity is being reviewed at test sites in the U.S. Injection wells are currently regulated through the UIC program, which requires site characterization, testing, and monitoring. "More research is recommended on developing site selection criteria and operational constraints for CO_2 storage sites near zones of seismic concerns."[59]

Environmental risks include concern about the re-release of carbon dioxide, ultimately undoing the benefits of sequestration. There is no guarantee that sequestered carbon won't leak. "However, in the petroleum producing areas of the United States, oil and gas deposits, as well as naturally occurring carbon dioxide gas, have been trapped underground for millions of years."[60] This issue also would depend on the size of a re-release, noting the overall net reduction in emissions realized by a sequestration project. Some in the scientific community also raise concerns about sequestration encouraging a continued reliance on fossil fuels, environmental issues associated with pipeline expansion, and impacts to biological communities that live deep underground.[61]

There also are risks associated with terrestrial carbon sequestration. There are no national standards for establishing baselines, so baseline calculations could change over time. Baseline estimates are needed to calculate the carbon reductions accomplished by a project. Monitoring risk is another issue, depending on how liability is assigned. "For example, utilities that purchase carbon credits from farmers may be held liable if farmers fail to follow through with promised emission reduction activities."[62] Reduced investment profitability because of changing economic factors, like changing output prices and interest rates, also may be considered financial risks.

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[58] http://www.bigskyco2.org/FAQs-geologic.htm#PHHE

[59] "Issues Related to Seismic Activity Induced by the Injection of CO2 in Deep Saline Aquifers", J. Sminchak and N. Gupta, Batelle Memorial Institute, and C. Byrer and P. Bergman, National Energy Technology Laboratory.

[60] http://www.bigskyco2.org/FAQs-geologic.htm#EISCDR

[61] "Policy Context of Geological Carbon Sequestration", Union of Concerned Scientists: Citizens and Scientists for Environmental Solutions, page 4.

[62] "Setting Up a Tradable Carbon Offsets System: Risk, Uncertainty and Caveats", Department of Agriculture and Applied Economics, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University.

Benefits

It is challenging to categorize the benefits of carbon sequestration. They range from reducing greenhouse gas emissions to providing new markets for the agriculture industry. The National Energy and Technology Laboratory notes that sequestration works toward implementation of national energy policy goals to develop new technologies and supports international collaborations to reduce greenhouse gas emissions and intensity.

Sequestration can provide potential economic benefits in oil and gas fields via enhanced oil recovery. Some studies are also reviewing the ability of carbon sequestration to enhanced coal bed methane production. In terms of terrestrial sequestration, it is difficult to separate the benefits of carbon sequestration from other environmental benefits of a certain land use practice. For example, the introduction of cover crops or the conversion to conservation tillage from conventional tillage also reduces soil erosion, in addition to sequestering carbon.

The Public Interest Energy Research Program Research Development and Demonstration Plan prepared a report for the California Energy Commission, which includes a discussion of the co-benefits of carbon sequestration. That report is included in **Table 5**.

Table 5:

Co-Benefits of Carbon Sequestration	
Environmental	**Economic/Productivity/Energy**
Improved salmonid and wildlife habitat	Enhanced oil, gas, methane recovery
Improved soil and water quality	Increased plant and crop productivity
Reduction in soil erosion and runoff	More biomass products
Decreased nutrient loss	Development of exportable technologies
Decreased water and pesticide use	Reduced dependence on oil imports
Restored degraded ecosystems	Decreased energy use through bioenergy, i.e., trees can lower reflectivity and cooler temperatures
Increased biodiversity	Rural economic growth

Increased water conservation	
More sustainable land use and food production	
Reduction in concentrations of GHGs, including methane and nitrous oxide	

Sources: Pew 2001, USDOE 1999, USDA 1998

Conclusions

This draft report and its related findings are intended to fulfill the work plan related to carbon sequestration, as approved by the ETIC in October 2007. The ETIC is providing this report as an informational tool for lawmakers, lobbyists, and the general public to better understand the science of carbon sequestration and the regulatory issues surrounding the subject.

With major questions remaining on the subject of jurisdiction based on activity at the federal level, development of a regulatory framework specific to sequestration proved extremely difficult. Without answers concerning jurisdiction, questions about liability and cost cannot be adequately addressed. However, in an effort to ensure that Montana lawmakers remain involved in the decisionmaking process regarding sequestration and to ensure that Montana interests are protected, the ETIC recommends continued attention and study of the issue.