The Carbon Question: An Overview of Technologies, CCAC Recommendations, Liability, Ownership, and Costs/Benefits

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Introduction

With the first meeting of the 2007-08 Energy and Telecommunications Interim Committee (ETIC) in July 2007, committee members ventured into what is widely referred to as the "carbon conundrum." Members reached a consensus that a significant portion of committee time for the interim would be spent considering a potential policy or regulatory framework as it relates to carbon sequestration in Montana. Members requested a study to review specific aspects of sequestration to determine where modifications to existing law or additions to the law may be considered. To reach its goal, the committee first 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 information on the feasibility of sequestration overall in Montana.

Based on the work plan adopted by the ETIC, members will review seven specific issues related to sequestration:

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

✔An examination of methods and technologies for the geological and terrestrial sequestration of carbon.

✔A review of the findings and recommendations of the Montana Climate Change Advisory Committee related to carbon sequestration.

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

✔A review of existing state and federal regulations governing carbon sequestration.

✔The costs and benefits of carbon sequestration.

✔A review of the liability issues related to sequestration and legal issues related to surface vs. subsurface, ownership issues.

This report is based on the most up-to-date information available. However, it should be noted that new information is being developed every day on this topic. A report provided to ETIC members in October discussed feasibility, sources and volumes of carbon produced in Montana, and existing state and federal regulations. This report and the October report will be merged and updated and provided to the committee in advance of the January meeting.

It also should be noted that on October 11, the Environmental Protection Agency (EPA) announced plans to establish rules for geological sequestration. The regulations will ensure that a permitting system for CO_2 injection is consistent with what is now in place under the Safe Drinking Water Act, according to the EPA. The Safe Drinking Water Act is established under the

Underground Injection Control (UIC) program. The EPA plans to propose regulatory changes to the UIC program in the summer of 2008. Due to federal primacy, unless the federal government opts to allow states to petition for their own rules, the EPA then would set the regulations for CO_2 injection. This issue is further discussed in the liability section of this report.

Methods and technologies

✔An examination of methods and technologies for the geological and terrestrial sequestration of carbon.

Since 2005, the Department of Energy has set aside about $145 million to put toward 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, Washington, and Oregon. Researchers are focusing on geologic and terrestrial field validation tests to determine the "relative efficiency of alternative sequestration options, prove the environmental efficacy and sustainability of sequestration, verify regional CO_2 sequestration capacities and satisfy project permitting and regulatory requirements."[1] 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."[2]

Geological Carbon Sequestration

To capture carbon, CO_2 is extracted from waste gases created during fossil fuel combustion. It is liquefied and 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 geologic sites for CO_2 storage including depleted oil reservoirs, unminable coal seams, carbonate saline aquifers, and basalt formations. **Figure 1** outlines these storage options in Montana. The partnership has found that CO_2 sequestration storage potential in depleted oil and gas fields in Montana is about 1 billion metric tons of CO_2. Saline aquifers in the state present about 200 billion metric tons of CO_2 storage potential. For a location to be used for such storage, it must have a caprock or a layer above the reservoir that is impermeable. The domes are often shaped like an upside-down bowl that traps the carbon and ensures it doesn't escape into the atmosphere. In terms of geological sequestration, the information included in this report will

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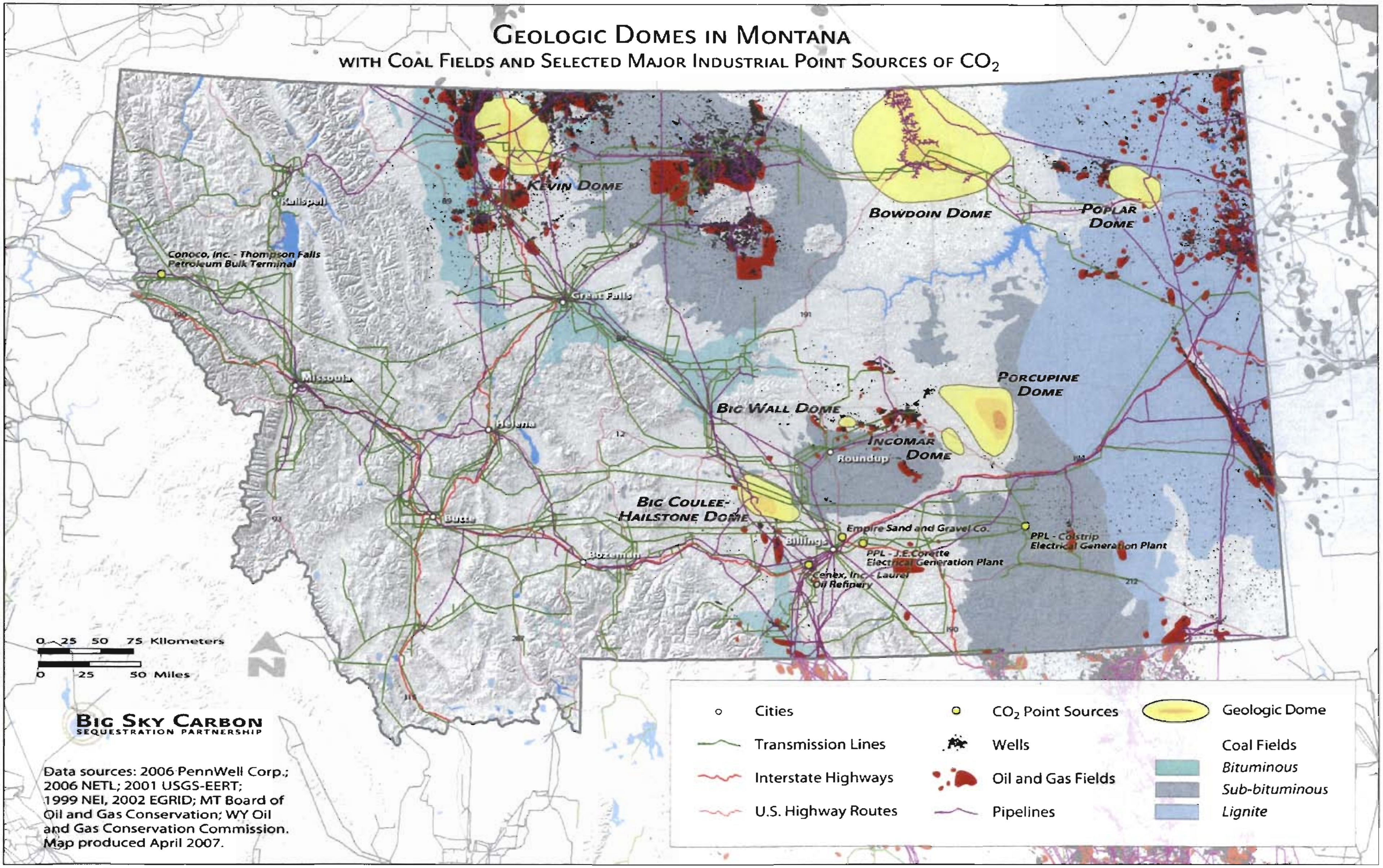
[1] http://www.bigskyco2.org/Overview.htm

[2] Ibid.


Geologic Domes in Montana
with Coal Fields and Selected Major Industrial Point Sources of CO_2
Kevin Dome
Bowdoin Dome
Poplar Dome
Porcupine Dome
Big Wall Dome
Incomar Dome
Big Coulee-Hailstone Dome
Conoco, Inc. - Thompson Falls Petroleum Bulk Terminal
Kalispell
Great Falls
Missoula
Helena
Butte
Bozeman
Billings
Roundup
Empire Sand and Gravel Co.
PPL - J.E.Corette Electrical Generation Plant
Cenex, Inc. - Laurel Oil Refinery
PPL - Colstrip Electrical Generation Plant
0 25 50 75 Kilometers
0 25 50 Miles
N
Big Sky Carbon Sequestration Partnership
Data sources: 2006 PennWell Corp.; 2006 NETL; 2001 USGS-EERT; 1999 NEI, 2002 EGRID; MT Board of Oil and Gas Conservation; WY Oil and Gas Conservation Commission. Map produced April 2007.
Cities
Transmission Lines
Interstate Highways
U.S. Highway Routes
CO_2 Point Sources
Wells
Oil and Gas Fields
Pipelines
Geologic Dome
Coal Fields
Bituminous
Sub-bituminous
Lignite

focus specifically on those geological areas.

Enhanced oil recovery

Since the early 70s, engineers have been putting carbon dioxide into oil reservoirs to increase oil production. Enhanced oil recovery (EOR) 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. The carbon makes the oil expand so it flows more easily. In the U.S. there are currently 70 CO_2 injection projects, injecting about 35 million tons of CO_2 for EOR.[3]

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 the 20-year project. The project results in an annual 1 million tons of carbon dioxide being sequestered rather than sent into the atmosphere. In October, committee members heard a presentation about the Beulah plant.

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 Corp. is beginning work on a CO_2 EOR project in the South Glenrock and Big Muddy fields east of Casper, Wyo. They are working to recover an additional 10% to 15%of the original oil. The Enhanced Oil Recovery Institute estimates that as much as 60% of the original oil reserves can remain unproduced after conventional recovery methods are used.[4] The Big Sky Carbon Sequestration Project also is working in Wyoming and looking at EOR.

Wyoming industry officials are working to develop a wider network of CO_2 pipelines.[5] Oil producers in the southern Powder River Basin have said they would be interested in purchasing CO_2, if pipelines are developed to link areas to the north and east. **Figure 2** 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 sinks, not carbon recovered from energy 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 and researchers at Montana State University in Bozeman are examining these areas and looking at the potential to permanently

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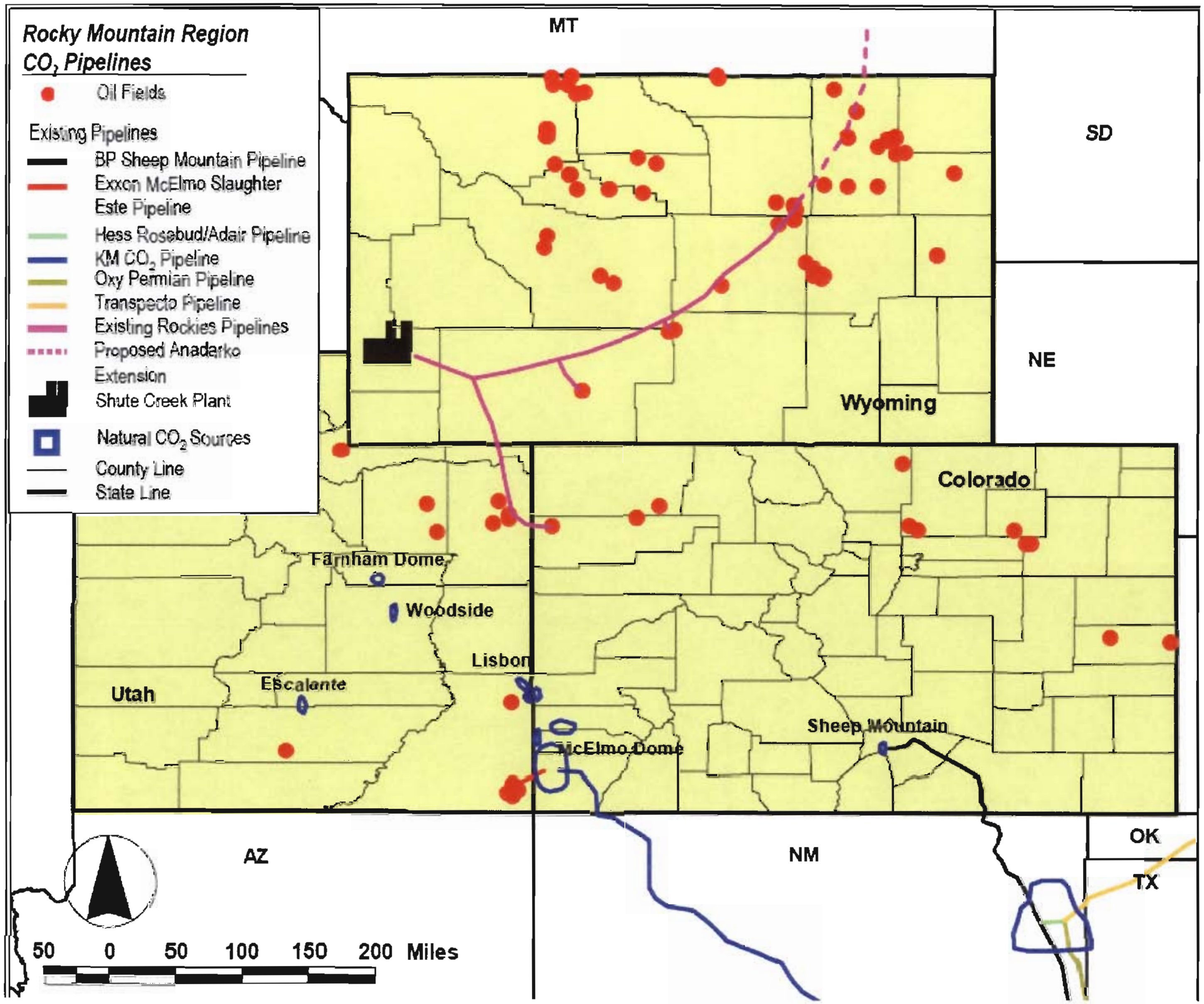
[3] "No time like the Present: NRDC's Response to MIT's 'Future of Coal' report," David Hawkins and George Peridas, 2007, page 4.

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

[5] *Casper Star Tribune*, "Oil Producers seek CO2", by Dustin Bleizeffer, June 27, 2007.



Advanced Resources International, 2006 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 3** includes a more in-depth look at that dome.

At a large-scale sequestration project in Norway, oil and gas company Statoil is injecting carbon dioxide directly from its Sleipner West natural gas production facility into the Utsira formation, a saline aquifer beneath the North Sea. The project has been underway since 1996, and Statoil reports that seismic surveys show that the injected gas has not leaked. The project has put 1 million tons of carbon dioxide into the aquifer every year.

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 coalbed methane. If a bed is used for sequestration, however, the injected coal cannot be mined in the future.[6] The Midwest Regional Carbon Sequestration Partnership is studying the feasibility of such storage. Some tests have shown that carbon dioxide is about twice as adsorbing on coal as methane, which gives it the potential to displace methane and remain underground. Limited field tests have demonstrated CO_2 recovery of coal bed methane, but more study is needed to optimize such a process.[7] A number of unmineable coal seams are located near generation facilities, or sources of carbon dioxide in the U.S., which would mean a limited pipeline structure would be needed, if such sequestration is developed.

Basalt formations (not Montana specific)

Within the region being studied by the Big Sky Carbon Sequestration Partnership, volcanic basalt covers 85,000 square miles, and preliminary calculations show 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 the gas moves underground and watch for leaks. "Basalt formations may offer a unique geological medium for long-term, secure carbon

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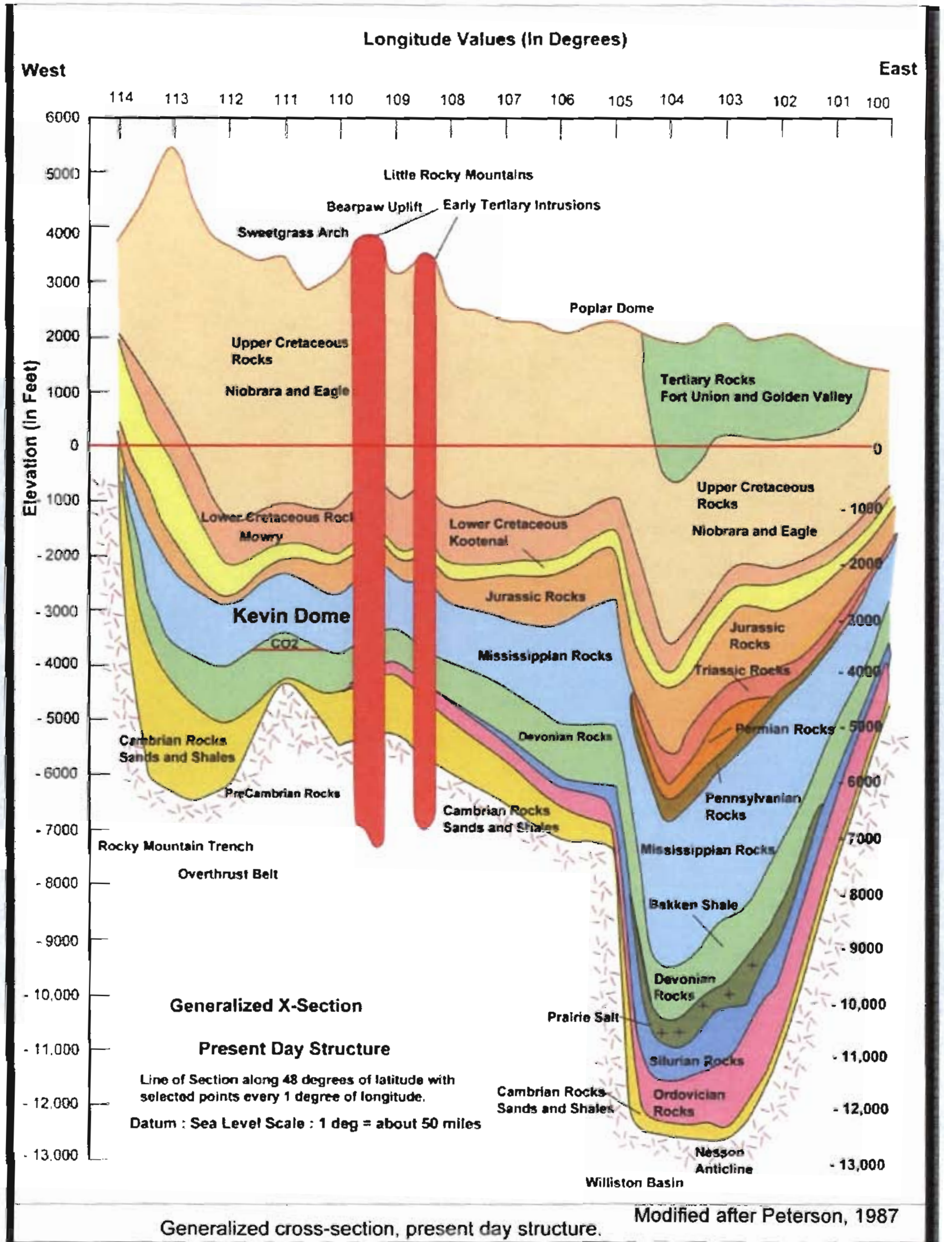
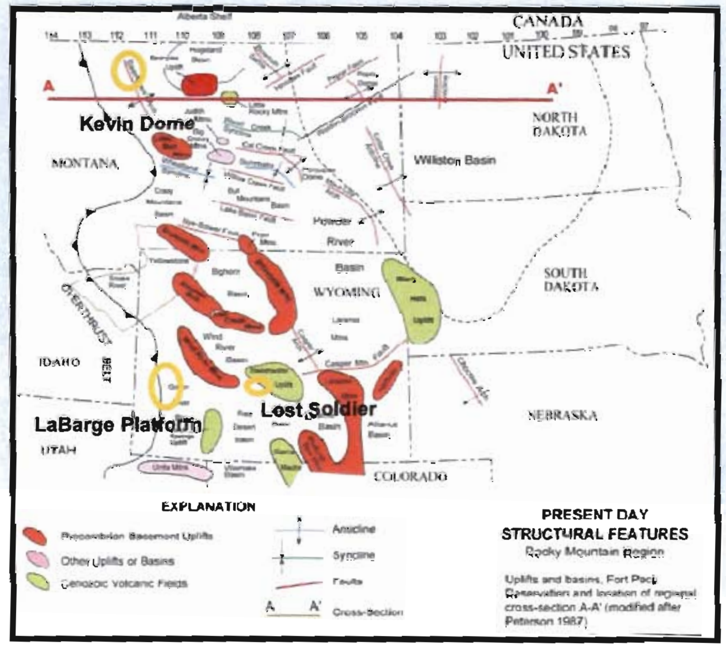
[6] *Assessing Carbon Sequestration Potential for "Unmineable" Coal Beds in Eastern Kentucky,* Greb, Weisenfluh and Eble, Kentucky Geological Survey, University of Kentucky.

[7] http://www.cslforum.org/index.html

Kevin Dome cross-section



Generalized cross-section, present day structure. Modified after Peterson, 1987



sequestration".[8]

Terrestrial Sequestration

Major agricultural states can potentially sequester more than 8% of the 1.9 billion metric tons of greenhouse gas emitted in the United States annually, according to a report by the U.S. Department of Agriculture. Agricultural and forestry practices can reduce greenhouse gases by maintaining existing carbon storage in trees and soils. Carbon sequestration units (CSU's) are 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 CSU's can then be packaged into portfolio's 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, like the National Carbon Offset Coalition, 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 .32 metric tons per acre per year during the nonfallow year. Credits can be earned between 2006 and 2010 on registered acres. Carbon is currently trading at about $3.20/ton. Carbon exchange rates for rangeland are earned at a rate of .12 to .24 metric tons per acre per year of CO_2 sequestered on eligible land. To put some of the numbers in perspective, terrestrial sequestration supporters say under current prices, a farmer with an operation that is verified by a third party can get $250 to $350 a year for 100 acres.

In northcentral Montana there are at least two projects taking place to monitor and verify terrestrial carbon offsets. One project is in its fifth 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 per acre.[9] Mulch farming and conservation tillage are agricultural processes that return biomass to the soil. Crop rotation, agroforestry systems, and application of bio-solids 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

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

[9] Estimates of sequestration rates used throughout provided by the National Carbon Offset Coalition.

tillage, can sequester about 0.1 – 0.3 metric tons of carbon per acre per year (Lal et al. 1999; West and Post 2002).[10]

Rangeland

Soil testing before and after planting have shown rangeland can hold up to a fifth of a ton of carbon per acre. Grazing management that employs sustainable stocking rates, rotational grazing, and seasonal use on non-degraded rangelands are considered practices eligible to be integrated into a trading system. Other applicable practices include restoration of degraded rangelands through sustainable stocking rates, rotational grazing, and seasonable use grazing.

Methane Offsets

The estimated 100 million cattle in the U.S. emit about 5.5 million metric tons of methane per year, around 20% of methane emissions in the nation, according to the EPA. Agricultural methane collection and combustion systems placed into operation after January 1999 also 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.

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 per year. The Nez Perce tribe has 4,000 acres that it has planted with trees in multiple projects on the reservation.[11] Beetle infestations, drought and other considerations are necessary in this area of 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.

Montana Climate Change Advisory Committee

✔A review of the findings and recommendations of the Montana Climate Change Advisory Committee related to carbon sequestration.

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

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[10]http://www.epa.gov/sequestration/faq.html

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

The MCCAC was made up of 18 members representing industry, environment, local and tribal governments, transportation, and agriculture.[12] 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 also worked with the MCCAC to develop possible policy options for reducing greenhouse gas emissions. The MCCAC voted on individual policy recommendations that will be presented to the Governor for possible implementation. In November a draft report on the recommendations will be presented to the ETIC, with a focus on recommendations related to carbon sequestration.

The MCCAC reached unanimous consensus on about 55 recommendations for reducing greenhouse gas emissions in the state to1990 levels by 2020. Those draft recommendations will be presented to you by DEQ Director Richard Opper, who also will be available to answer additional questions.

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 has or is currently working in 15 other states to develop greenhouse gas reduction plans.

Five technical working groups organized to advise the full MCCAC and provide technical analysis of greenhouse gas policy options. 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.

Those working groups flushed out recommendations of "high priority mitigation options". Those recommendations then went to the full MCCAC for discussion. The MCCAC reached agreement on finalizing recommendations based on those options in early July 2007. The draft summary report is provided in **Appendix A**. There are some caveats attached to that report, however. The draft is an evolving document, and the final draft summary was not available prior to the release of this report. That report is expected to be final in the coming months, potentially making some of these discussion points obsolete.

The general recommendations, statewide goals, and energy supply recommendations relating to carbon and sequestration include:

- Montana should develop a mandatory greenhouse gas reporting protocol that will apply to all sectors.

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

- Reduce greenhouse emissions in Montana to 1990 levels by 2020 and an additional 80% reduction by 2050.

- Montana should lead by example and state government should reduce its greenhouse gas emissions to 1990 levels by 2018.

- Montana should participate in the Climate Registry.

- Montana should develop a periodic, complete inventory of greenhouse gas emission sources and sinks on a continuing basis with forecasts.

- The state should implement a public education and outreach program to support greenhouse gas emissions reduction efforts at all levels.

- Utilities should be required to supply 20% of their load from renewable sources of energy by 2020 and 25% by 2025. Measures to increase electricity production at existing hydroelectric facilities should be considered eligible for the renewable standard.

- Montana should provide incentives to increase the supply of renewable energy in the state and reduce its cost.

- Montana should seek funds to help develop and deploy technologies for energy storage and advanced fossil fuels.

- The state should provide incentives and remove barriers for combined heat and power and distributed generation projects.

- Montana should establish a requirement that all fossil fuel-fired power plants meet a technology fuel-neutral emissions level expressed in tCO_2MWh and as needed to achieve this level, file a plan with the DEQ that details the facility's commitment to capture CO_2 and implement terrestrial and or geological sequestration as a part of operating plans and permits. The specific requirement would be established through rule making by the Montana Board of Environmental Review. The CCAC recommends that the DEQ petition for such a rule, and that the Legislature approve supporting language. It also recommends a CO_2 emissions capture goal of $0.5tCO_2/MWh$ (or 1,100 lbs./MWh or 50%) increasing commensurate with the implementation of best available control technology.

- The state should provide incentives to encourage emissions reductions at power plants through increased efficiency and co-firing.

- The CCAC recognized the difficulty in implementing a cap and trade program without national participation and urged Governor Schweitzer to join the Western Regional Climate Action Initiative to send a signal to Congress to act on this issue.

- Montana should strengthen the Major Facility Siting Act to enable eminent domain for pipelines to transport CO2 and protect landowners with appropriate siting requirements, while addressing liability issues.

- The state should investigate and implement policies to encourage the reduction of greenhouse gas emissions per MWh produced or, in the case of renewable facilities, encourage an increase of output at existing facilities.

- The state should require utilities to acquire electricity only from generation sources that capture and sequester CO_2 to a level equivalent to that accompanied by a natural gas combined cycle plant (about 50%).

- Best Management Practices, including the EPA Natural Gas STAR program, should be implemented in Montana for methane and CO_2 reductions in oil and gas operations.

- Montana should require than any future coal-to-liquids refineries capture and store CO_2 from the start of operations and co-fire some fraction of biomass.

Liability and surface vs. subsurface rights

✔A review of the liability issues related to sequestration and legal issues related to surface vs. subsurface issues.

Liability and oversight

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. In addressing the liability question, first party insurance, direct government regulation combined with insurance, payments out of the tax system, 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."[13]

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[13] "Towards a long-term liability framework for geological carbon sequestration," M.A. de Figueiredo, D.M. Reiner, and H.J. Herzog, May 2003.

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 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. 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 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:

> "The oil and gas developer or operator is responsible for all damages to property, real or personal, 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 property, real or personal, caused by drilling operations and production."

The Board of Oil and Gas 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 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 clean-up 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."[14]

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. The owner or operator must have a permit issued by the EPA under the UIC program. These would be materials injected that do not fall under Class II, which the Montana Board of Oil and Gas oversees. Class I wells

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[14] "Towards a long-term liability framework for geological carbon sequestration," M.A. de Figueiredo, D.M. Reiner, and H.J. Herzog, May 2003.

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."[15]

There are at least three potential injection frameworks for carbon dioxide. It has been discussed under both the Class I and Class II regime. 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-sale projects. . . On the basis of the data collected, the Agency may consider developing regulations tailored specifically for CO2 injection."[16]

As noted earlier in this report, the EPA on Oct. 11 announced its intentions to develop rules governing injection controls for carbon dioxide. This may mean the EPA will examine existing classifications or even develop a new classification for injecting carbon underground. Agency officials have said the regulations will be released for public comment by the summer of 2008.

During the October ETIC meeting, members heard from the Montana DEQ Water Protection Bureau on the injection issue. The Montana Water Quality Act in Title 75, chapter 5, MCA provides 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 groundwater.

In looking at other states for guidance in this area, there are limited examples. The Kansas Legislature recently enacted H.B. 2419, the "Carbon Dioxide Reduction Act," which requires its Corporation Commission to adopt specific rules and regulations establishing "requirements, procedures and standards for the safe and secure injection of carbon dioxide and maintenance of underground storage of carbon dioxide." Those rules must be in place by July 2008. The commission also may establish fees for permitting, monitoring, and other activities.

Wyoming, North Dakota, and New Mexico are currently examining liability and storage vs. surface rights issues. Draft legislation that is being discussed in Wyoming, assigns the Wyoming Oil and Gas Commission oversight and regulation responsibilities related to sequestration. The New Mexico Climate Change Advisory Group in late 2006 recommended the Oil Conservation District be the agency that oversees and implements the regulatory framework for geological

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15 http://www.gwpc.org/e-library/e-library_documents/e-library_documents_uic/classi.htm

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

sequestration. California legislators are discussing forming a "Carbon Capture and Geological Sequestration Standards Board." The ETIC in October received a report from the Interstate Oil and Gas Compact Commission outlining its recommendations for a policy framework and recommended state oversight. Legislation being discussed in Wyoming on the subject also was provided to ETIC members.

The recent EPA announcement may circumvent state efforts in this arena. In the case of Class II wells, the EPA allowed states to petition to oversee such injection permitting. In Montana the Board of Oil and Gas, for example, oversees the Class II permits. It is unknown if such a petition may be allowed in the case of regulating the injection of carbon dioxide over long periods of time.

Surface and sub-surface rights

Property with underground pour 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 Interstate Oil and Gas Compact Commission 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. In October the ETIC also heard from the Northern Plains Resource Council, where surface and sub-surface rights were discussed. Concerns about eminent domain, enforcement, accountability, and liability were all raised.

ETIC staff attorney Todd Everts prepared a legal opinion on the topic of surface and sub-surface rights in Montana to assist committee members in a discussion about ownership issues. That opinion is included in **Appendix B**.

Economics

✔The costs and benefits of carbon sequestration.

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, 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 a $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.[17] 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 economic 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 $4 a ton.

The Big Sky Carbon Sequestration Partnership and other research organizations have provided some preliminary economic analysis related to carbon capture and sequestration. They offer the following analysis of costs per kilowatt hour:

Figure 4

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
Without 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: IPCC

Based on the above chart, 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 integrated gasification combined cycle plant. "The costs of retrofitting existing power plants with CO_2 capture have not been extensively studied."[18] The feasibility and costs of capture, however, vary widely based on size, age, and efficiency of a plant.

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

[18] "Carbon dioxide capture and storage: Summary for policymakers and technical summary," Intergovernmental Panel on Climate Change, executive summary.

PPL Montana, which is an operator at the Colstrip Steam Electric Station, believes 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. They have looked at three options for retrofitting:

Figure 5

PPL Montana estimates for carbon capture			
Technology	**Capital Cost**	**O&M**	**CO_2 removal cost per ton**
Amine Scrubber Process -- (capture carbon in flue gas)	$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 downstream of 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

Other cost considerations in the carbon capture process include the cost of compressing carbon. For example, at a 600 MW plant, operation and maintenance of a compression system can result in about $38 million in electric costs. However, some compression systems can provide $22 million in electricity recovery. Integration of the compression system when carbon capture is used is then obviously significant.

Pipeline costs are another consideration. The bottom line is that pipeline infrastructure is expensive. 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. They have examined those costs in terms of the varying contract lengths. Usage fees are likely to be low in general, making the fixed fee a better option. 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%. With the expected high costs of infrastructure, the credit worthiness of shippers is critical, according to the analysis.

Figure 6

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

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 design, market depth, standard contracts, 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 (Constitutional issues would need to be considered), the federal government, EOR producer coalitions, utility buyers of generation output, and CO_2 producers, according to the Pipeline Authority.

John Antle, a professor of Agriculture Economics at Montana State University in Bozeman, is working on a series of economic analysis reports related to carbon sequestration in Montana. The findings will integrate all aspects, terrestrial and geological, for carbon sequestration in the region (as defined by the Big Sky Carbon Sequestration Partnership.) To date, a lot more work in analyzing the costs of terrestrial sequestration has been completed. For now, the economic analysis related to geological sequestration is focused on sequestration for EOR and sequestration in deep saline aquifers. The economic analysis will aim to quantify the costs and quantities of CO_2 sequestered. It will include the costs of capture at electric power plants, transportation from source to sink, and injection costs. It will link up potential sinks with carbon sources in the region and then look at the associated costs. Research in this area is ongoing.

<u>Risks</u>

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 member 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.[19] In 1986 a village in the African nation of Cameroon was 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 due to movement of displaced fluids. When CO_2 is injected, it can react with salt water 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 groundwater by layers of dense rock."[20] Some scientists believe that dissolved carbon dioxide plumes would not seep into groundwater, and monitoring could show plume migration. Pumping could be used to prevent contamination, if a plume was nearing groundwater, according to some researchers. 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."[21]

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."[22] Some in the scientific community also raise concerns about sequestration encouraging a continued reliance on fossil fuels, environmental concerns associated with pipeline expansion, and impacts to biological communities that live deep underground.[23]

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

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

[21] "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.

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

[23] "Policy context of geological carbon sequestration," Union of Concerned Scientists: Citizens and Scientists for Environmental Solutions, page 4.

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."[24] Reduced investment profitability because of changing economic factors, like changing output prices and interest rates, also may be considered financial risks.

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 enhance 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 **Figure 7**.

Conclusions

This report is intended to fulfill a portion of the work plan related to carbon sequestration, as approved by the ETIC in October. At its previous meeting, members heard presentations and received materials related to carbon emissions in Montana, regulatory framework considerations, and the feasibility of sequestration in areas of Montana. This report is intended to offer background information on methods and technologies for sequestration, findings and recommendations of the MCCAC related to sequestration, costs and benefits of sequestration, and a review of liability and ownership issues.

As additional information is collected and the EPA moves forward on its planned regulatory framework related to the UIC program, information provided to the committee will be updated.

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[24] "Setting up a tradeable 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.

Figure 7:

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. tries 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.

Montana's Climate Change Advisory Committee

Montana Department of Environmental Quality

I. Background:

On December 13, 2005, Montana Governor Brian Schweitzer directed Richard Opper, Director of the Montana Department of Environmental Quality, to develop a statewide Climate Change Action Plan. Governor Schweitzer issued his directive in response to the lack of leadership by the federal government on the climate change issue.

To develop the plan, Opper formed an 18-member Climate Change Advisory Committee consisting of representatives of the following interests in the state:

- agriculture,
- environmental advocacy groups,
- state and local government,
- energy production,
- the public,
- home builders,
- academics,
- state legislators, and
- labor unions

In addition, a 6 member Scientific Advisory Panel was appointed including statewide experts in carbon sequestration, forestry, climate science and carbon offsets.

To help facilitate the planning process and to provide additional scientific expertise, the state contracted with the Virginia-based Center for Climate Strategies (CCS). The CCS team was formed in 2004 to support states and other entities in the creation and management of climate change mitigation plans and policies. They have worked on projects with Arizona, California, Colorado, Connecticut, Maine, Minnesota, New Mexico, North Carolina, Oregon, Pennsylvania, South Carolina, Rhode Island and Washington. They have also worked on the West Coast Governors Global Warming Initiative, the Western Regional Air Partnership, and the New England Governors/Eastern Canadian Premiere's Climate Agreement of 2001.

The Montana Department of Environmental Quality provided logistical support for meetings, facilities, and public notice, with assistance by CCS. Other state agencies participated as advisors to the process.

II. The Planning Process:

The process began with examination of a comprehensive catalog of possible state actions. The Climate Change Advisory Committee identified priority options, which were analyzed by CCS in terms of costs and reductions of greenhouse gas emissions. For each draft potential policy option identified by the Climate Change Advisory Committee, CCS prepared a policy option template, for the council's review and approval. Historical emissions, carbon storage inventories, and reference case projections were developed by CCS for years 1990-2020.

A final report is being prepared by CCS to document the Climate Change Advisory Committee's recommendations on each policy option, including alternative views as needed. The meeting notes and final recommendations can be found on the joint state/CCS website at the following address: www.mtclimatechange.us.

III. Results of Montana's GHG Inventory:

Montana produced approximately 36.7 million metric tons (MMt) of gross consumption-based carbon dioxide equivalent (CO_2e) emissions in 2005. This represented 0.6% of total U.S. gross greenhouse gas (GHG) emissions. Montana's gross GHG emissions increased 14% from 1990 to 2004, while national emissions rose by 21% during this period. Although Montana's GHG emissions are low compared to the total national output, on a per capita basis, Montanans emit about 40 metric tons (Mt) of CO_2e, much higher than the national average of 25 $MtCO_2e$.

The principal sources of Montana's GHG emissions are electricity use and agriculture, each accounting for about 27% of Montana's gross GHG emissions. Transportation is close behind at 20%.

A. Agricultural Emissions:

The relative contribution of agricultural emissions (methane and N_2O emissions from manure management, fertilizer use, and livestock) is much higher in Montana (26%) than in the nation as a whole (7%). This is a result of more agricultural activity per capita in Montana compared to the U.S.

B. Electricity Generation Emissions:

Montana electrical power plants produce considerably more electricity than is consumed in the state. Since 2000, Montana has exported to other states roughly 40% of the electricity it produced.

Montana electricity generation has been primarily a mix of coal and hydroelectricity. Generation from these two sources has been almost equal in some years, but recently coal sources have dominated. In 2004, coal accounted for 65% of generation, hydro for 33%, fuel oil for 2%, with the remaining sources (natural gas, biomass, and wind) contributing less than 0.5%. Those percentages will change as a result of a major wind farm coming online in 2005. Coal-fired power plants produce as much as twice the CO_2 emissions per Megawatt-hour of electricity as natural gas-fired power plants, which dominate other states' production.

C. Transportation Emissions:

The next largest contributor to emissions is the transportation sector. Within the transportation sector, gasoline-powered vehicles account for about 60% of the GHG emissions and diesel fuel consumption accounts for another 34%.

D. Projected Emissions:

If no actions are taken to reduce its production of greenhouse gasses, Montana's gross GHG emissions are projected to climb to 42 $MMtCO_2e$ by 2020. This is an increase of 31% over 1990 levels. Transportation is projected to be the largest contributor to future emissions growth, followed by fossil fuel production and electricity use in the state.

Montana was historically a net sink of GHG emissions due to a strong forestry and agricultural land base that ties up carbon in terrestrial sinks. However, due to the increase of GHG emissions since 1990 and the projected increase in emissions through 2020, this situation is changing. Montana is estimated to have transitioned from a net sink to a net source of GHG emissions before 1990. By 2020, the net emissions are estimated to be about 16 $MMtCO_2e$/yr in Montana.

IV. Summary of GHG Reduction Options:

The Climate Change Advisory Committee produced a list of 55 recommendations. Some of those recommendations can be implemented immediately; some will require action by the state legislature. Some of the recommendations will cost money to implement; others will save money for the state. In general, the costs of implementing all of the committee's recommendations will be balanced by the savings the state will realize by using less energy more wisely. The Montana Department of Environmental Quality, with considerable help from the CCS Team, will incorporate the committee's recommendations into a statewide action plan, which will be provided to the Governor in October, 2007.

The council's recommendations are listed below. They are divided into general recommendations/statewide goals, and those that impact specific sectors of Montana's economy.

A. General Recommendations/Statewide Goals:

- Reduce greenhouse emissions in Montana to 1990 levels by 2020 and an additional 80 percent reduction by 2050.
- Montana should lead by example and state government will seek to reduce its greenhouse gas emissions to 1990 levels by 2018.
- Montana should develop a periodic, complete inventory of greenhouse gas emission sources and sinks on a continuing basis with forecasts.
- Montana should develop a mandatory greenhouse gas reporting protocol that will apply to all sectors.
- Montana should participate in the Climate Registry, a 30 state-member organization to track and encourage greenhouse gas reductions. (Montana has already joined this organization.)
- The State should implement a public education and outreach program to support greenhouse gas emissions reduction efforts at all levels.

B. Energy Supply:

- Utilities should be required to supply 20 percent of their load from renewable sources of energy by 2020 and 25 percent of 2025. Measures to increase electricity production at existing hydroelectric facilities should be considered eligible for the renewable standard.
- Montana should provide incentives to increase the supply of renewable energy in the state and reduce its cost.
- Montana should seek funds to help develop and deploy technologies for energy storage and advanced fossil fuels.
- The State should provide incentives and remove barriers for combined heat and power and distributed generation projects.
- Montana should establish a requirement that all fossil fuel-fired power plants meet a technology fuel-neutral emissions level expressed in $tC0_2MWh$-and as needed to achieve this level-file a plan with the DEQ that details the facility's commitment to capture $C0_2$ and implement terrestrial and or geologic sequestration as a part of operating plans and permits. The specific requirement would be established through rule making by the Montana BER. The Climate Change Advisory Committee recommends that the DEQ petition for such a rule and that the Legislature approve supporting language. It also recommends a $C0_2$ emissions capture goal of 0.5 $tC0_2/MWh$ (or 1100 lbs./MWh or 50%) increasing commensurate with the implementation of best available control technology.

- The State should provide incentives to encourage emissions reductions at power plants through increased efficiency and co-firing.
- The Climate Change Advisory Committee recognized the difficulty in implementing a cap and trade program without national participation and urged Governor Schweitzer to join the Western Regional Climate Action Initiative to send a signal to Congress to act on this issue.
- The State should require utilities to acquire electricity only from generation sources that capture and sequester $C0_2$ to a level equivalent to that accomplished by a natural gas combined cycle plant (about 50 percent).
- Best Management Practices, including the EPA Natural Gas STAR program should be implemented in Montana for methane and $C0_2$ reductions in oil and gas operations.
- Montana should require that any future coal- to-liquids refineries capture and store $C0_2$ from the start of operations and co-fire some fraction of biomass.

C. Residential, Commercial, Institutional and Industrial:

- Montana should implement demand side management programs to decrease the use of electricity and natural gas. This could include financial incentives to provide alternate rate schedules, audit programs and technologies such as efficient ground-source heat pumps, on-demand water systems and Energy Star appliances.
- Montana should join the Northwest Energy Efficiency Alliance to help encourage consumers to implement cost-effective energy efficiency practices.
- Montana should work with other regional states to develop a market for appliances with higher efficiency standards.
- Montana should review existing building codes and increase standards for minimum performance. Residential and commercial codes should also be increased by 15% by 2010 and 30% by 2020.
- Montana should go beyond the existing building code by providing regulatory and financial incentives to reduce consumption of electricity and natural gas by 20% by 2020 in existing buildings and 50% in new buildings by 2020.
- Montana should implement consumer education programs related to energy efficiency and the environmental consequences of energy and other choices.
- Montana should implement a program to provide voluntary energy audits of industries for energy efficiency opportunities.
- Montana should increase energy efficiency by 30 percent in 50% of eligible low-income residential units by 2015 and 50 percent in 75% by 2020.
- Montana should provide energy consumers with price and other

information via 'smart' metering to allow consumers to clearly identify the outcomes of their choices.

D. Transportation and Land Use:

- Montana should adopt the State Clean Car Program (also known as the "Pavley" standards or California GHG Emission Standards) in order to reduce GHG emissions from new light-duty vehicles.
- Montana should set minimum energy efficiency standards for replacement tires and requiring that greater information about Low-Rolling Resistance (LRR) replacement tires, including the availability of all season/all weather LRR tires, be made available to consumers.
- Montana should provide incentives for Scan Gauge, Air Alert Valve Cap technologies that provide consumers with information about the fuel efficiency and cost in relation to the purchase, maintenance, and operation of their vehicles.
- Montana should study and develop policy options that create financial incentives and disincentives for the purchase and operation of vehicles with varying fuel economy including labeling for buyer information, excise taxes for high emitting vehicles and rebates for low emitting vehicles.
- Montana should implement a set of growth and development policies including Smart growth planning, open space protection, mixed use development, expanding transit opportunities, Brownfield redevelopment, etc.
- Montana should seek to increase the use and market penetration of Low Carbon Fuels to offset traditional fossil fuels such as gasoline, diesel, jet fuel and others derived from crude oil. Methods may include carbon fuel accounting, low carbon fuel standard, high carbon fuel tax, etc.
- The State should encourage the retrofit of on-road heavy-duty diesel vehicles to reduce particulate emissions with standards and incentives.
- Montana should reduce fuel consumption from heavy-duty diesel vehicle idling at rest areas and truck stops through voluntary actions, incentives, contractual mechanisms and standards with eventual enforcement.
- Montana state and local government agencies should "lead by example" by enacting procurement policies and or joining the EPA SmartWay program and utilizing the SmartWay Upgrade Kits that result in adoption of lower emitting vehicle fleets.
- The State should seek to reduce emissions from the transportation sector through improvements to transportation system management. These efforts would focus on the improvement, management, and operation of the transportation infrastructure.
- Montana should study ways to promote intermodal transportation.
- Montana should reduce emissions from off-road engines through

retrofits, programs to reduce emissions from RV's, lawn and garden equipment and emissions standards.

- The state should encourage the federal government to reduce GHG emissions from the aviation portion of the transportation sector.

E. Agriculture, Forestry and Waste Management:

- Montana should promote conservation tillage, no till fanning and other soil management practices to increase the level of organic carbon in the soil.
- Montana should produce sufficient biodiesel from Montana feedstocks to meet 2, 10 and 20 percent of 2004 levels of Montana petroleum diesel consumption by 2010, 2015 and 2020.
- By 2010, achieve in-state production levels of 50 million gallons/year of starch based ethanol production capacity and 2 million gallons/year of cellulosic production. Increase to 110 mgy of starch based and 25 mgy of cellulosic by 2015 and 250 mgy of starch and 50 mgy of cellulosic by 2020.
- Montana should retain crop acres in the conservation reserve program (CRP) that were scheduled for retirement from the program and achieve no net conversion of CRP acreage though 2020.
- Preserve Open Space.
- Increase usage of woody biomass residue for renewable electricity, heat and steam generation by 200,000 tons/year above 2006 levels by 2020.
- The State should ensure re-stocking on 20% of the accessible forest lands impacted by stand replacement fires since 2000 to stocking rates of 200-400 trees/acre. For future lands impacted by wildfire, re-stock forestlands impacted by stand replacement fires within 5 years after fire.
- Montana should initiate programs to increase forest productivity by 20% on 700,000 acres of private and state forest lands by 2020.
- Montana should adopt programs to expand the use of wood products by 5% over current baseline.
- Thirty percent of the food consumed in Montana should be grown, harvested and processed in Montana by 2020.
- Montana should increase solid waste recycling rates to 17% by 2008, 22% by 2011, 25% by 2015 and 28% by 2020.