

Carbon Dioxide White Paper
Prepared for the Wyoming Joint Minerals, Business and
Economic Development Interim Committee
October 4, 2006

Executive Summary

Carbon dioxide (CO₂) can serve as a meaningful catalyst to enhancing recovery from Wyoming's world class oil fields.

Development of CO₂ pipeline infrastructure into the Big Horn and Powder River Basins, where there are large volumes of remaining oil in place, could provide Wyoming with formidable tax revenue in the future.

In order to enhance oil development and advance clean coal conversion technologies within the State, new CO₂ infrastructure must be developed in order to connect supply to market. Many of the advanced coal plant sponsors indicate that they will not build their facilities unless they have comfort that CO₂ generated from their facilities can be sequestered. Wyoming's oil fields and its deep saline aquifers offer a perfect repository for existing and future CO₂ supply sources.

With the exception of Texas, other States competing to host advanced coal facilities within their borders do not have infrastructure in place to sequester the CO₂. Wyoming should develop a strategy to incentivize development of carbon dioxide infrastructure so that it can capture the benefits of enhanced oil recovery within its borders and

attract advanced coal facilities dependent upon the ability to sequester their CO₂ output.

We suggest that development of all CO₂ infrastructure within the State of Wyoming be coordinated through a joint effort of the Wyoming Pipeline Authority and the Enhanced Oil Recovery Institute. Ideally, carbon dioxide producers and end use markets will be incentivized to work with the two Wyoming entities through sales tax and/or severance tax incentives associated with development of pipeline facilities and utilization of CO₂ in oil fields – first within the State and ultimately, within the region. Wyoming stands to benefit from development of CO₂ infrastructure within the State by having less carbon dioxide produced into the atmosphere and by enhancing oil output.

Existing Carbon Dioxide Supply Sources

Currently, Exxon's Shute Creek facility serves as the supply source for all carbon dioxide (CO₂) enhanced oil recovery projects within the Rocky Mountain region. Approximately 250 MMcfd of CO₂ is contracted to Chevron, Anadarko and Merit Energy for use in the Rangely field of Colorado, and the Monell, Salt Creek and Bairoil Fields of Wyoming respectively. Approximately 100 MMcfd of intermediate pressure, "high quality CO₂" is currently being vented by Exxon at their Shute Creek facility along with approximately 100 MMcfd of waste stream gas that contains roughly 55% CO₂ and 45% nitrogen. Exxon is in the process of finalizing long term contracts for the remaining "high quality CO₂" that is being vented at its facility.

We understand that Chevron, Anadarko and Merit are the parties contracting for the additional CO₂. Exxon anticipates that this stream can be put to beneficial use in the region by early 2008 once an additional compressor is installed at its existing facility to boost the gas stream from roughly 65 psig to the 2250 psig operating pressure of its existing pipeline. Estimated cost to install the additional compressor and associated facilities is approximately \$60 million. Lead time for new compressor deliveries is running 12 to 18 months.

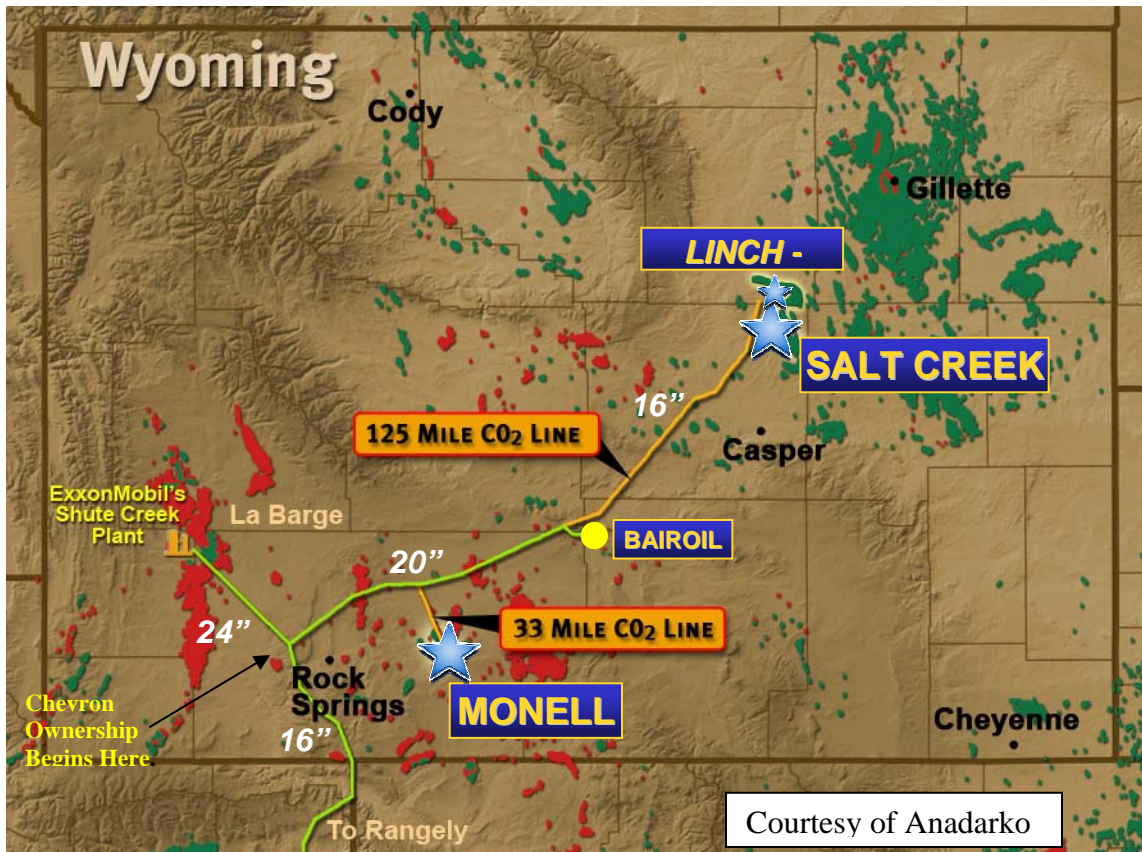
Many other sources of CO₂ supply exist within the State of Wyoming and within the Rocky Mountain region but, quite often, the cost to capture (compress) and purify alternative sources of supply outstrips its potential value without additional incentives being applied. Exxon's carbon dioxide/nitrogen stream is being vented at atmospheric pressure which means that a tremendous amount of compression would have to be added in order to get the supply into its pipeline which operates at about 2300 psig. Additionally, the cost to separate nitrogen from any gas stream can be inordinately expensive.

Conoco/Burlington's Madden facility currently vents the only other stream that could readily be put to use in enhancing oil recovery in Wyoming or the region's oil fields. Estimates put the cost of capturing and delivering the Madden supply (which is approximately 55 MMcfd) at between \$1.35 and \$2.00 per thousand feet of CO₂ delivered. The high cost is due to the compression and pipelining necessary to put the carbon dioxide into a "marketable" condition.

Coal fired power plants emit roughly six times more CO₂ than all of Wyoming's oil and gas fields combined. These emissions are at atmospheric pressure and currently there is not a viable economic method by which to capture this carbon dioxide and separate it from the various other contaminants in the smokestack emission. Too, there is no rate incentive for an electric company to install the technology necessary to capture CO₂ and put it to beneficial use in the oil fields or sequester it underground (i.e. if an electric company expends capital on capturing emissions, it wants to be able to capture recovery of that capital in its rate base from consumers as well as commercial and industrial customers. Many Public Utility Commissions in the west are also reluctant to allow for cost recovery of emission control equipment.)

Existing CO₂ Infrastructure

Primary infrastructure for delivery of CO₂ within the region is owned by three companies (or their affiliates): Exxon, Chevron and Anadarko. Exxon owns the infrastructure from Shute Creek through Rock Springs and on to Bairoil. Chevron owns the infrastructure from Rock Springs to Rangely. Anadarko owns the infrastructure from Bairoil to Salt Creek. A diagram of the existing carbon dioxide infrastructure in the region is illustrated below:



CO₂ Can and Will Increase Crude Oil Recovery in the State

The Wyoming Geologic Survey estimates the following sources of CO₂ within the State of Wyoming as well as the amount of CO₂ that could be put to work in the oil fields along with the associated “potential” incremental oil recovery that the State could anticipate if recovered carbon dioxide could be put to beneficial use:

Sources of Carbon Dioxide

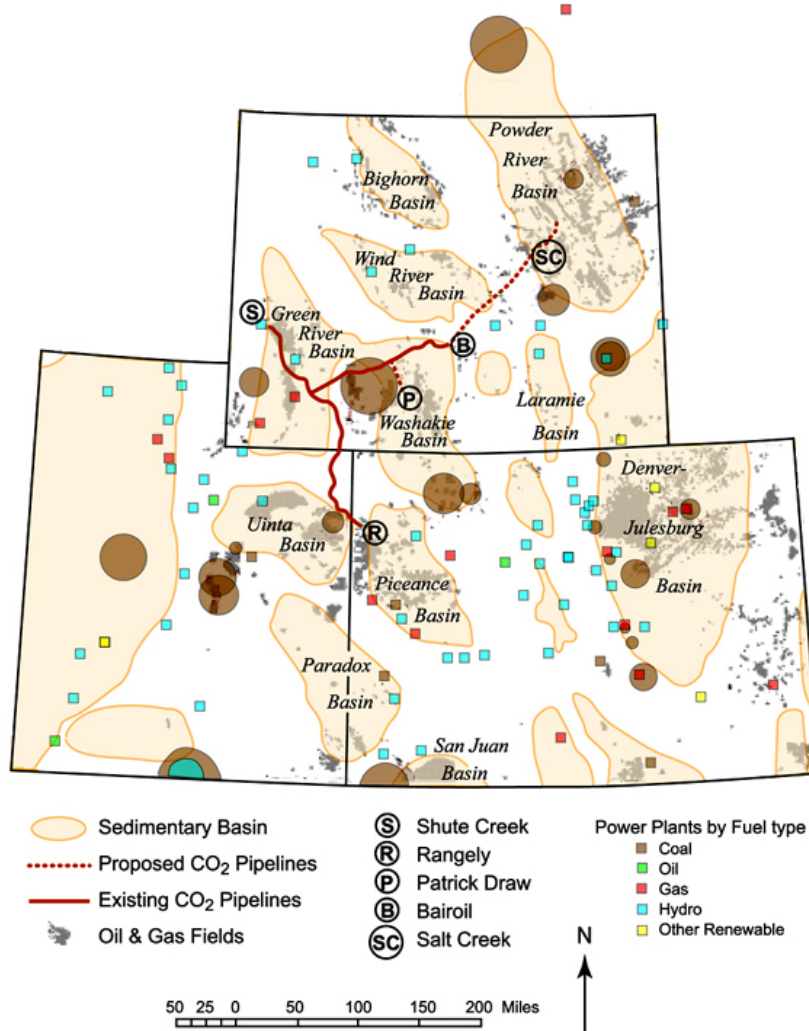
LaBarge: 9.7 MM tons/yr

Madden: 1.2 MM tons/yr

Power plant release: 58 MM tons/yr

Carbon Dioxide Requirements Over Time

OOIP in WY candidate reservoirs: 8 billion barrels of oil
 CO2 flooding recovers 10 -15% of OOIP
 EOR potential: 0.8 – 1.2 billion barrels of oil
 CO2 required: 460 – 700 MM tons total

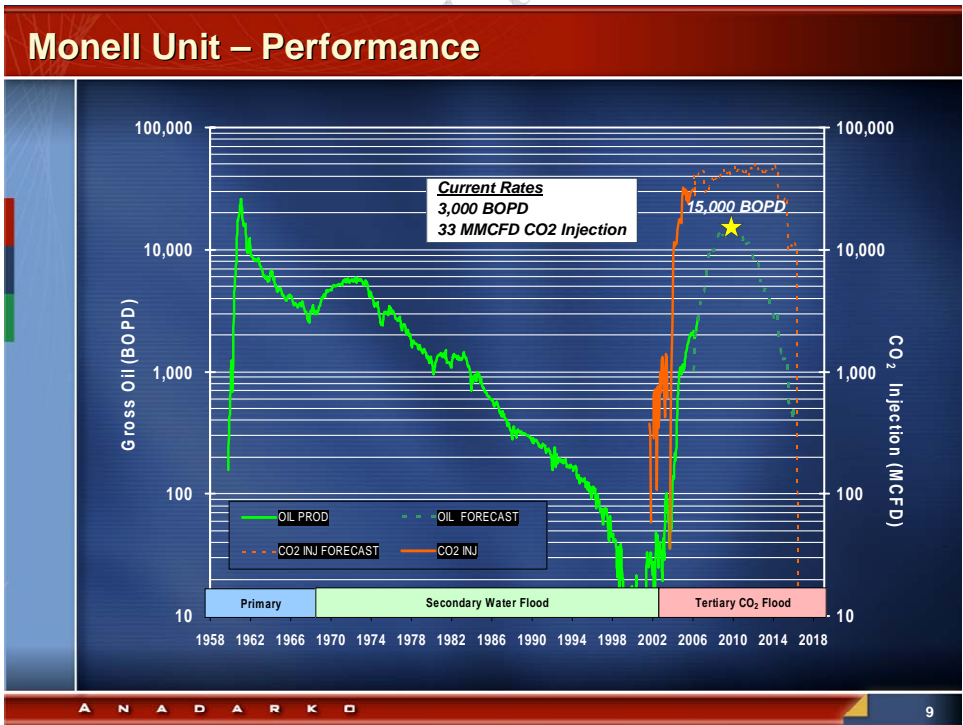
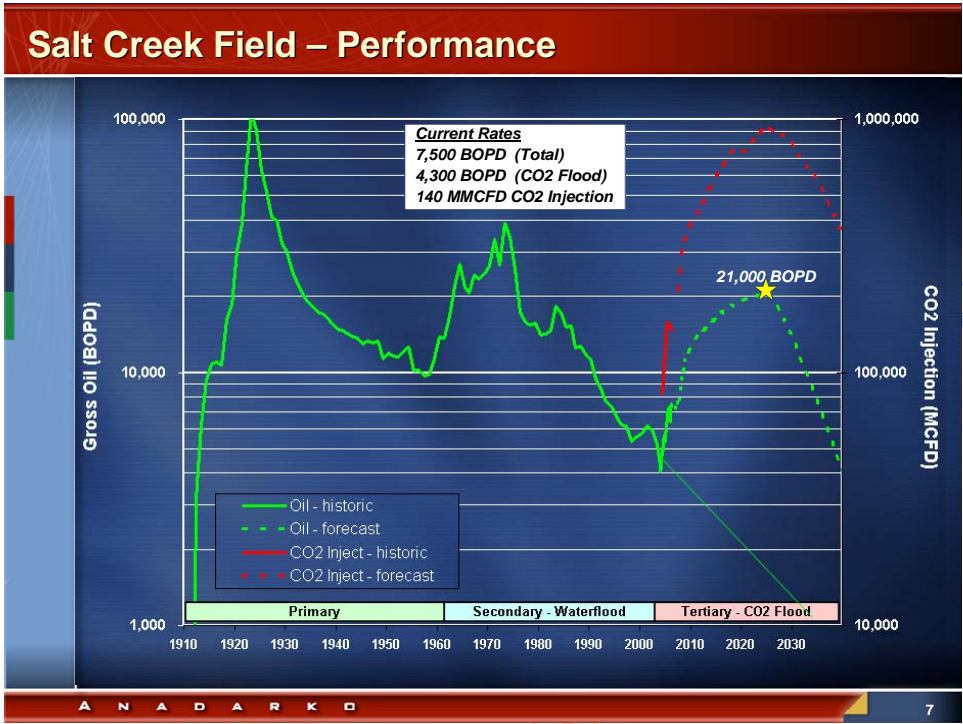


Source: Wyoming Geologic Survey

Note: Brown circles represent CO₂ sources associated with coal fired power plants.

Similarly, Wyoming's Enhanced Oil Recovery Institute estimates a recoverable 320 million barrels of oil from the Powder River Basin alone.

Field response to Anadarko's CO₂ enhanced oil recovery efforts within Wyoming are encouraging as is illustrated below:

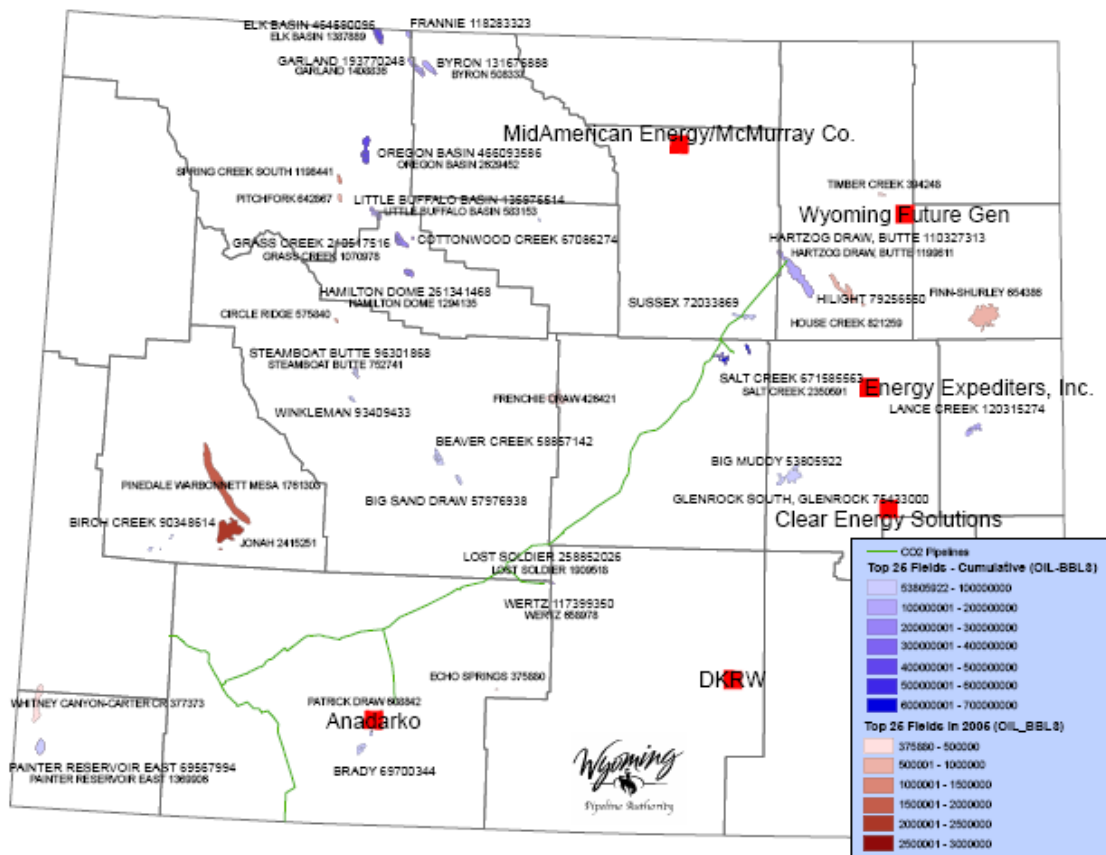


Source: Anadarko Petroleum

Future Carbon Dioxide Supply Sources

Much of the incremental oil remaining and/or left to be recovered within the State resides in the Big Horn Basin and Powder River Basin. These are areas where no CO₂ infrastructure currently exists.

Potential future sources of CO₂ supply from advanced coal plants are illustrated below in red:



Source: Wyoming Pipeline Authority

In addition to the potential CO₂ supplies that may come from advanced coal conversion plants, supplies may be available from other areas – especially if commodity prices remain at the levels they are currently at. Specifically, Exxon and other operators have expressed an interest in developing additional and/or accelerating existing reserves in the deeper sour gas trend of SW Wyoming – provided they can find a place to sequester CO₂ supplies developed with such reserves.

In the Baxter Basin of SW Wyoming, large potential natural CO₂ reserves exist at fairly shallow depths and could be developed to promote enhanced oil recovery within the State of Wyoming and the Rocky Mountain region.

At this time, recovery of CO₂ from smokestack emissions does not appear to be economically or technically feasible.

Conclusion

We believe that the potential exists to recover substantial amounts of additional oil within the State of Wyoming and the Rocky Mountain region if new CO₂ supplies and infrastructure can be developed. Development of CO₂ infrastructure may have to precede or occur coincidentally with development of advanced coal conversion plants if Wyoming desires to “get a leg up on” other states competing to have these facilities sited within their borders. We encourage the

legislature to advance development of carbon dioxide infrastructure and advanced coal facilities within the State. Development of such infrastructure is not inexpensive or without risks. However, the rewards in putting CO₂ to beneficial use within the State and to sequestering CO₂ from advanced technology coal conversion techniques should provide the State a meaningful revenue platform for the future.

Consider this paper a work in progress. The Wyoming Pipeline Authority awaits your further guidance.

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