U.S. Department of Energy
in cooperation with
Minnesota Department of Commerce

MESABA ENERGY PROJECT

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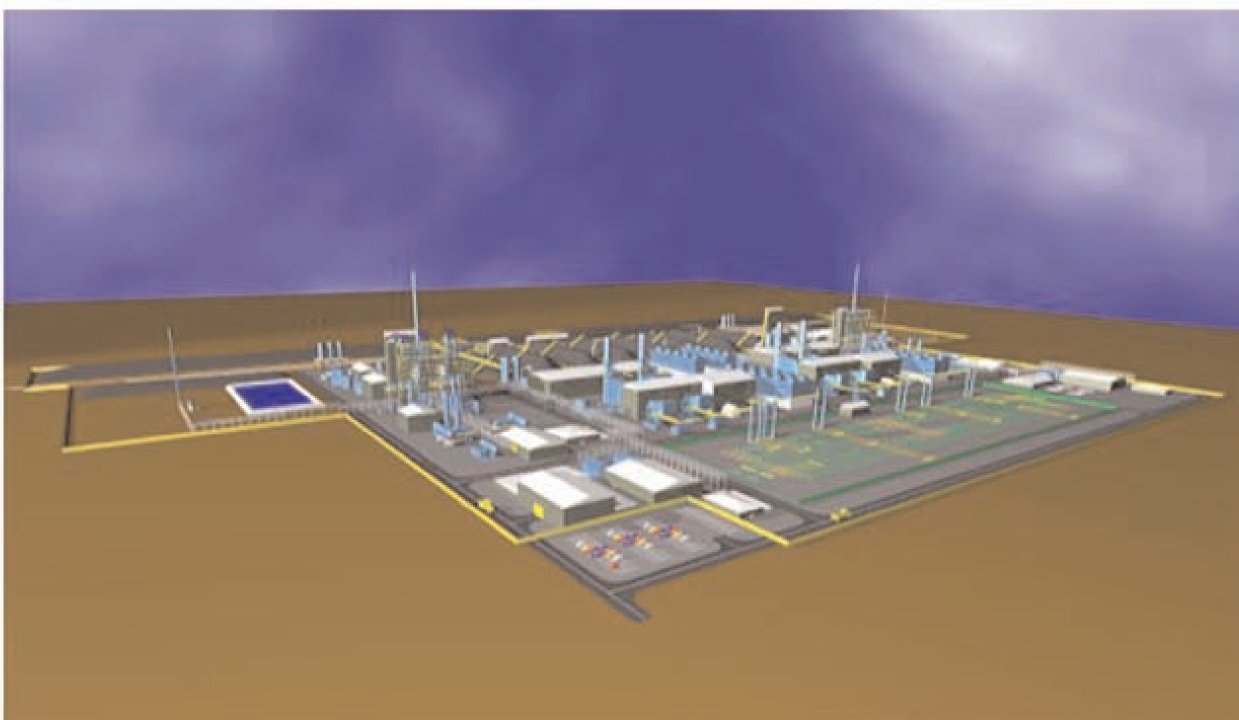

NOVEMBER 2007

Office of Fossil Energy
National Energy Technology Laboratory

APPENDIX A

Carbon Capture and Sequestration –

Excelsior's Plan (A1),
DOE Analysis of Feasibility (A2)

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APPENDIX A1
Excelsior's Plan for Carbon Capture and Sequestration

(Note: Color versions of figures in this Appendix are included in the file posted at the DOE NEPA website: http://www.eh.doe.gov/nepa/docs/deis/deis.html)

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PUBLIC VERSION

Mesaba Energy Project

Mesaba One and Mesaba Two

Plan for Carbon Capture and Sequestration

Prepared by

EXCELSIOR ENERGY INC.

October 10, 2006

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Executive Summary

Excelsior Energy Inc., the developer of the Mesaba Energy Project has prepared this plan to identify the opportunities for capture and sequestration of carbon dioxide ("CO_2") emissions from its integrated gasification combined-cycle ("IGCC") power stations. This carbon capture and sequestration plan ("CCS Plan") was prepared to provide a concrete option for the State of Minnesota to meet its obligations under future CO_2 regulations, which if promulgated, would affect coal-fired power plants, including the Mesaba Energy Project. We undertook the plan with the goal of providing the Minnesota Public Utilities Commission (the "Commission") with information about all options that are available now and in the future with respect to carbon management through capture and geological sequestration from the Mesaba Project.

The decision to implement a carbon capture and sequestration ("CCS") program is one that the Commission must weigh from time to time, based upon the costs to ratepayers associated with CCS and the benefits to ratepayers associated with a CCS program. This Plan provides a framework within which the Commission can make such a decision. The costs to ratepayers of implementing CCS would include additional capital and operating costs, reduced output and plant efficiency, and potential downtime to implement the system. The benefits would include any revenues from enhanced oil recovery ("EOR"), and the ability to cost-effectively comply with any form of legislation limiting or regulating carbon dioxide emissions as part of an initiative to stabilize atmospheric concentrations of greenhouse gases ("Carbon Constraints"), whether in the form of avoiding carbon taxes or the purchase of allowance credits, or the ability to reduce carbon emissions to levels specified on a fleetwide or statewide basis.

The first option for CCS presented by the Mesaba Project entails capture and sequestration of carbon dioxide present in the syngas, which represents 30% of the total carbon dioxide emissions from the plant. Technologically, this option would entail the installation of amine scrubbers downstream of the acid gas removal system in the IGCC power stations to remove up to 85% of the CO_2 in the synthesis gas that fuels the plants. This process would result in an overall CO_2 capture rate of 30% for the plant. This technology is available now to achieve 30% capture at a relatively low cost to ratepayers. This option could be implemented as early as 2014, following the commercial operation date for the first unit of the Mesaba Energy Project. Implementation of CCS prior to the availability of credits or carbon avoidance benefits would rely exclusively on revenues that may be available from EOR. Sequestration at EOR sites would have higher costs, due to the longer distances to the candidate oil fields, than would sequestration in saline formations closer to the plant site. Those additional costs would be weighed against the revenues that would accompany the supply of CO_2 for EOR. A decision to implement this form of CCS prior to the imposition of Carbon Constraints would have to weigh the likelihood that the base line emissions year would be established such that reductions implemented before that date would be given credit.

The second, longer-term option for CCS presented by the Mesaba Project would reduce CO_2 emissions by approximately 90%. This option could be implemented following the successful demonstration by the United States Department of Energy's FutureGen project of full capture from an IGCC plant. The costs of this option are significantly higher than the 30% capture approach using currently available technology. Significant ongoing research and development efforts sponsored by the Department of Energy ("DOE") are expected to reduce these costs significantly and result in commercial offerings of these technologies. Given the fact that IGCC is a least-cost source of carbon reductions in the power sector,[1] these deeper reductions are likely to be cost justified in the event Carbon Constraints are imposed that require any meaningful reduction in total greenhouse gas emissions. Implementation of the 30% capture option would not preclude later decisions to increase capture levels to 90%.

In an EOR scenario, the captured carbon dioxide would be transported via pipeline to oil fields in North Dakota, southwestern Manitoba, and/or southeastern Saskatchewan. Once the CO_2 arrives at its destination, it would be sequestered underground, potentially in connection with enhanced oil recovery operations.

Alternatively, the saline formation scenario would entail transporting the CO_2 to a saline formation located much closer to the plant site, reducing the pipeline costs but also eliminating the revenues associated with the sale and beneficial use of the CO_2.

The economics of CCS look promising. The 30% capture option identified in the CCS Plan would enable CO_2 capture at a cost per ton below that of any other existing power plant in the state.[2] IGCC plants' ability to economically capture CO_2, combined with the potential for revenues described above, have the potential to significantly decrease the cost of CCS.

Under this proposed CCS Plan, Excelsior would commit to undertake capture, transportation and sequestration of carbon dioxide, upon a decision by, and at the direction of, the Commission, upon approval of a modification to the proposed power purchase agreement that would allow for Excelsior to be compensated at a reasonable cost of capital for the necessary capital investments, and to be made whole on the other costs associated with the CCS program. This commitment, together with Excelsior's ongoing work to refine the costs and technical means to implement CCS, will position the state to respond in a timely and economic fashion to carbon constraints.

I. Introduction

This ability to capture and sequester CO_2 is important because Carbon Constraints are likely to be implemented within the next ten years. As evidence of this, various proposals to regulate

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[1] See the Oct. 10, 2006 testimony of Douglas H. Cortez, OAH Docket No. 12-2500-17260-2, MPUC Docket No. E-6472-/M-05-1993. Also, see presentation by Julianne M. Klara, NETL/DOE, Gasification Technologies Conference, *Federal IGCC R&D: Coal's Pathway to the Future*, Oct. 4, 2006, a*vailable at* http://gasification.org/Docs/2006_Papers/49KLAR.pdf.

[2] According to a compilation of studies by the Intergovernmental Panel on Climate Change, the net cost of 90% capture for an IGCC plant is $18/ton less than a new supercritical coal plant and $30/ton less than a new natural gas plant. This difference would increase significantly when considering 30% capture at an IGCC plant, and increase further when compared to retrofitting existing plants. As Minnesota currently has no identified geological sequestration options, pipeline costs would be significant for any plant in the state. Even allowing for a shorter pipeline, no existing or new non-IGCC power plant in Minnesota could capture at a price per ton as low as Mesaba Energy Project. Intergovernmental Panel on Climate Change, *IPCC Special Report: Carbon Dioxide Capture and Storage*, p. 25 (2005), *available at* http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/ccsspm.pdf.

greenhouse gas emissions ("GHGs") have been introduced in the United States Congress, and various states have embarked upon their own GHG programs.

Identification of strategies to comply with likely Carbon Constraints is a critical element of protecting Minnesota's consumers and economy. Excelsior is working in conjunction with the Energy and Environmental Research Center ("EERC") as part of the Plains CO_2 Reduction Partnership ("PCOR") initiative to develop CO_2 management options for the Mesaba Energy Project based on evaluations of sequestration opportunities associated with regional geologic formations/features and nearby terrestrial features.[3]

What follows is Excelsior's CCS Plan for the first two of six IGCC units to be constructed over time on three state-authorized sites within the Taconite Tax Relief Area of northeastern Minnesota. The proximity of the three sites with IGCC units, together with the potential opportunities for carbon sequestration identified by the EERC, affords the State of Minnesota the opportunity to carefully plan for and implement the most cost-effective and flexible response to carbon constraints.

II. Background: Mesaba Energy Project Phases I and II

The IGCC Power Station described in this document consists of Phase I and Phase II of the Mesaba Energy Project ("Mesaba One" and "Mesaba Two," respectively). Each phase is nominally rated at peak to deliver 606 megawatts ("MW") of electricity to the bus bar.

Excelsior has submitted the necessary regulatory petitions and preconstruction permit applications to support construction of Mesaba One and Mesaba Two. The key pending regulatory filings made in connection with the Mesaba Project include the following: On December 22, 2005, Excelsior submitted to the Commission a petition to approve a Power Purchase Agreement with Xcel Energy under Minn. Stat. § 216B.1693 and 1694. On June 16, 2006, Excelsior submitted a Joint Permit Application for a Large Electric Power Generating Plant Site Permit, a High Voltage Transmission Line Route Permit, and a Natural Gas Pipeline Route Permit to the Commission for Mesaba One and Mesaba Two. On June 28, 2006, Excelsior submitted applications for New Source Review Construction Authorization and National Pollutant Discharge Elimination System Permits to the Minnesota Pollution Control Agency for Mesaba One and Mesaba Two. On June 29, 2006, Excelsior submitted an application for a Water Appropriation Permit to the Minnesota Department of Natural Resources.

When operational, the Mesaba Energy Project will allow Minnesota and the nation to benefit from the environmental advantages that IGCC technology offers over conventional, solid fuel alternatives. Beyond its capability for achieving an emission profile unmatched by conventional coal combustion systems, IGCC is adaptable to capture significant amounts of carbon dioxide

[3] The EERC is part of the University of North Dakota and has been selected by the Department of Energy to develop a regional vision and strategy for dealing with carbon management in the Plains Region (including the Canadian Provinces of Alberta, Saskatchewan, and Manitoba, and the states of Montana, NE Wyoming, North Dakota, South Dakota, Nebraska, Minnesota, Wisconsin, Iowa, and Missouri). *See* PCOR Partnership Profile, http://www.undeerc.org/pcor/partnership.asp.

from the synthesis gas prior to its combustion. Mesaba One and Two will be configured to allow for the installation of additional equipment that can capture up to 30% of the potential carbon in its selected feedstock.

III. Regulatory Context for Carbon Capture and Sequestration

Excelsior's intent in proposing a framework for CCS is to commence a process to identify and define conditions for development of CCS when state or national considerations require GHG reductions, and/or when such reductions might otherwise become an economic choice for the ratepayers of Northern States Power Company under the PPA, in the context of Mesaba One and Mesaba Two. Excelsior's efforts will advance state decision makers' practical knowledge regarding the role IGCC and the Mesaba Energy Project can play in achieving actual reductions in the state's CO_2 emissions.

Several states are undertaking initiatives to reduce greenhouse gas emissions, most notably carbon dioxide, in isolated sectors of their economies.[4] To achieve significant reductions of such emissions, it is probable that future climate change initiatives will extend nationwide and to all sectors of the economy. The ability to physically reduce the volume of GHG emissions from Minnesota's economic activity will be a critical component to the state's economic health,

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[4] Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont have formed the Regional Greenhouse Gas Initiative ("RGGI") with the goal of creating a regional cap-and-trade program. The plan will begin addressing carbon dioxide emissions from power plants in the member states by capping 2009 carbon dioxide emissions at current levels. Beginning in 2015, RGGI states will begin reducing carbon dioxide emissions to achieve a 10% reduction by 2019. To facilitate the process, power plants will receive CO_2 emission allowances, which they may trade with other power plants. *See* Press Release, Regional Greenhouse Gas Initiative, States Reach Agreement on Proposed Rules for the Nation's First Cap-and-Trade Program to Address Climate Change (Aug. 15, 2006), *available at* http://www.rggi.org/docs/model_rule_release_8_15_06.pdf; Regional Greenhouse Gas Initiative, Model Rule (Aug. 15, 2006), *available at* http://www.rggi.org/docs/model_rule_8_15_06.pdf.

Similarly, California recently enacted legislation that calls for the development of regulations and market mechanisms that will reduce the state's greenhouse gas emissions by 25% by 2020. The law will impose mandatory caps beginning in 2012 and will incrementally tighten emission limits to reach the 2020 goals. *See* Press Release, Gov. Arnold Schwarzenegger, Gov. Schwarzenegger Signs Landmark Legislation to Reduce Greenhouse Gas Emissions (Sept. 27, 2006), *available at* http://gov.ca.gov/index.php?/press-release/4111/; California Global Warming Solutions Act of 2006, Assembly Bill No. 32, *available at* http://www.leginfo.ca.gov/pub/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf.

In 2001, Massachusetts developed regulations that apply to power plants in the state. Under the regulations, CO_2 emissions may not exceed the historical actual emissions for the three-year period from 1997 to 1999, and CO_2 emissions may not exceed 1800 lbs/MWh. See Massachusetts Dept. of Environmental Protection, Governor Swift Unveils Nation's Toughest Power Plant Regulations, Inside DEP, April/May 2001, at 1, *available at* http://www.environmentalleague.org/Issues/Enforcement/ DEPMay2001.pdf#search=%22Governor%20Swift%20air%20regulations%22; 310 Mass. Code Regs. 7.29 (2004), *available at* http://enviro.blr.com/display_reg.cfm/id/48436.

whether the constraints require roll-backs from any one sector or sources, or whether the constraints take the form of a tax or a cap-and-trade system. The precise form that the Carbon Constraints take is outside the scope of this CCS Plan, and in any event is not critical to the analysis of IGCC, which has the lowest cost of capture of any fossil fuel technology.[5] In a carbon-managed economy, large sources of CO_2 emissions that can economically achieve significant GHG reductions will likely be the major source of CO_2 offsets for other economic sectors whose only meaningful alternative for achieving reductions may be the purchase of GHG offset credits. Because IGCC is the technology best suited to carbon capture of all the fossil technologies,[6] it is a least-cost means to achieve actual reductions in GHG emissions, and will therefore very likely be able to achieve emission reductions at a cost below where credits will trade or where tax levels are established in order to signal sufficient reductions to meet the national program goals. Mesaba One and Mesaba Two are therefore likely to be ideal sources of carbon offsets under such circumstances, and are likely to provide the state with a meaningful, cost-effective hedge in meeting any federally-imposed GHG reductions.

IV. Preliminary Plan Description and Analysis

There are two primary components of the CCS Plan. First, Excelsior identifies the most promising, commercially available CO_2 capture technology to install at the IGCC power station. As described later in this section, an amine scrubber process currently has the most potential for carbon capture at the Mesaba Project. Second, Excelsior develops engineering plans for different methods of sequestering the captured CO_2. Based upon studies to date, the CCS Plan suggests a staged development of CO_2 pipelines from its Iron Range plant sites to North Dakota oil fields and proximate locations. The pipelines would likely utilize existing railroad, pipeline, or transmission line rights of way.

A. CO_2 Capture

Several processes have been proposed for carbon capture in coal power plants, consisting primarily of scrubbing or membrane separation-based processes. In conventional coal plants, the carbon must be scrubbed from very large volumes of stack gases at low pressures and temperatures. The most mature and proven of these is amine scrubbing, which is similar to the process used by the Mesaba Energy Project to capture sulfur from the syngas. In this process, the amine solution first adsorbs carbon dioxide from the gas being treated, and then CO_2-enriched amine is regenerated, recycling the amine and producing a relatively pure stream of CO_2.

IGCC plants enable pre-combustion capture of CO_2, which provides the intrinsic advantages of treating an undiluted and pressurized gas stream. An additional advantage enjoyed by IGCC is that CO_2 captured from high-pressure syngas requires less compression before transport and/or storage.[7]

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[5] See Ref. 1.
[6] *Ibid*.
[7] The volumetric flow of the pre-combustion IGCC syngas stream is far smaller than the post-combustion

The Mesaba Energy Project features a design that is adaptable to carbon capture, which enables relatively simple upgrades to be made in order to commence carbon capture. These upgrades entail installing a CO_2 amine scrubber downstream of the acid gas removal system and adding driers and compressors for captured CO_2. In this design, the CO_2 available for capture is limited by the proportion of carbon dioxide in the syngas, which varies for different fuels. Up to 30% of the potential CO_2 could be removed from the design subbituminous coal, while up to 20% could be removed from other design feedstocks.

Higher capture rates are not commercially available today, but will be demonstrated in the future. This is the primary objective of DOE's FutureGen project, which aims to capture at least 90% of the CO_2 from a non-commercial plant to begin operation in 2013. After such a demonstration of commercial viability, the Mesaba Energy Project could achieve 90% capture by adding a gas reheater and a water gas shift reactor upstream of the CO_2 amine scrubber. The shift reactor process converts CO to CO_2 by the following reaction:

$$CO + H_2O \rightarrow CO_2 + H_2$$

Nearly all of the carbon in the resulting syngas stream is in the form of CO_2, enabling the amine scrubber to remove at least 90% of the CO_2. However, at the current state of technology, this process would increase capital cost and reduce efficiency of the plant, making it more expensive for capturing CO_2 on a per ton basis than the 30% configuration. It should be noted that a plant that has implemented 30% capture would still be technically capable of being converted to capture 90% once the technology is demonstrated by DOE's FutureGen project.

Because the 90% approach has not yet been demonstrated and the 30% approach is the most mature and proven option, Excelsior concludes that the 30% approach is the most likely candidate for CCS in the near term. The 30% CO_2 capture configuration represents a cost-effective, commercially available option today for the Mesaba Project.[8]

B. Economic Considerations Relating to Sequestration

The potential economic drivers for CCS by the Mesaba Energy Project include opportunities to supply the CO_2 to an oil field for sale and use in enhanced oil recovery ("EOR"), and the opportunity for financial benefits to ratepayers from reductions in the costs of complying with carbon limits imposed in the future. This CCS Plan contains information on economical sequestration opportunities within the oil fields located in closest proximity to the Mesaba IGCC power stations. Because CO_2 used for EOR is also sequestered, the Mesaba Energy Project would likely earn carbon credit revenues (or avoid costs in other carbon limit scenarios) once regulations limit CO_2 emissions, which would be in addition to the EOR revenues. Therefore, investments in pipeline infrastructure for EOR will provide additional value as a method of sequestration once a carbon credit market is established.

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stream in a conventional coal plant, which enables the size of treatment equipment to be reduced. Also, as this treatment is conducted at approximately 400 psi, the additional compression required to pipeline the CO_2 is reduced.

[8] See the Oct. 10, 2006 testimony of Douglas H. Cortez, OAH Docket No. 12-2500-17260-2, MPUC Docket No. E-6472-/M-05-1993.

1. Enhanced Oil Recovery

Carbon dioxide has been proven to be very effective for secondary and tertiary oil recovery by both displacing and decreasing the viscosity of otherwise unrecoverable oil. Upon extraction of the oil, the EOR process easily removes pressurized CO_2 and recycles it by reinjecting into the pool. Economic benefits from EOR have been realized in at least two regions in North America. Kinder Morgan CO_2 has a CO_2 pipeline network of 1100 miles servicing the Permian Basin in western Texas and eastern New Mexico.[9] Similarly, the Dakota Gasification Project in the Northern Plains pipes CO_2 over 200 miles to the Weyburn oil field in southeastern Saskatchewan. The market for CO_2-based EOR is still available in oil fields across the country, so the Mesaba Energy Project, by virtue of its advanced stage of development, may be poised to exploit some of the most economical oil recovery operations available to the benefit of Minnesota ratepayers.

2. Carbon Credits or Other Economic Benefits of CCS

Carbon credits or other economic benefits derived from CCS under other forms of potential carbon regulation also represent a potential economic driver for the Mesaba CCS development, with future regulation in the U.S. determining the final value of the carbon benefits generated by CCS undertaken by the Mesaba Energy Project.

D. CCS Approach

This CCS Plan analyzes the most promising initial approach for CCS from the Mesaba Energy Project under present circumstances, which would entail capture of 30% of the CO_2 generated by the power stations and would direct that captured CO_2 to EOR sites. This approach requires a longer pipeline than would direct sequestering of CO_2 in closer, non-EOR sites. Therefore, targeting EOR sites will require higher front-end costs than if Excelsior were to sequester carbon simply to meet carbon limits without providing CO_2 for EOR opportunities. EOR and future carbon credit markets may offset the higher costs associated with initially targeting EOR sequestration sites.

While the timetable for implementation of regulations governing the operation of a carbon-managed economy is unknown, Excelsior anticipates that it would have adequate time to implement the power station upgrades and construct a CO_2 pipeline.

Numerous in-depth studies exist describing the technological means to capture 90% of the carbon dioxide from an IGCC plant.[10] Because of the real-time research and development efforts with respect to 90% capture, and the expected reductions in costs of this option as the technologies are demonstrated, Excelsior has not attempted to quantify the costs nor describe the technological approach in detail in this phase of the plan.

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[9] See Kinder Morgan CO_2, http://www.kindermorgan.com/about_us/about_us_kmp_co2.cfm.

[10] For a summary of such studies, see the Oct. 10, 2006 testimony of Douglas H. Cortez, OAH Docket No. 12-2500-17260-2, MPUC Docket No. E-6472/M-05-1993.

V. Currently Available Regional Sequestration Studies and Experience with CO_2 Pipelines

A. Regional Sequestration Studies

The EERC has extensively characterized three major types of sinks for carbon sequestration that are within the appropriate geographic proximity of the Mesaba Energy Project. The options are geological sequestration in oil fields (for enhanced oil recovery or storage only) or saline formations, and terrestrial sequestration (primarily using wetlands). Terrestrial sites are not suited to accommodate direct injection of CO_2 because such sites rely on changing the existing physical configuration of large areas of the earth's surface, rather than accepting the direct input of CO_2 at a stationary point. This CCS Plan focuses on geological sequestration, to which IGCC is uniquely suited.

Oil fields have proven to be CO_2 sinks with sufficient storage capacity to accommodate CCS projects equivalent to the long-term output of all six phases of the Mesaba Energy Project. Fields in the Permian Basin in western Texas have sequestered CO_2 for decades at scales even larger than those addressed in this CCS Plan.

During Phase I of the PCOR project, the EERC conducted exhaustive bottom-up characterizations of the EOR potential for each field in the PCOR region.[11] The EERC's methodology has produced reliable and conservative estimates of the CO_2 capacity for EOR in each field. This data forms the basis for the EOR-driven scenarios in the CCS Plan by the Mesaba Energy Project presented below. The economic benefits that could be achieved from EOR alone (that is, not including sales of carbon credits) are substantial. For example, the EERC projects that the total value of oil that could be recovered by EOR in North Dakota alone exceeds $15 billion (at a price per barrel of $59.50).[12]

Saline formations have the potential for still greater sequestration capacity than oil fields. The EERC's studies of the CO_2 sequestration capacity of the Broom Creek Formation in North Dakota have confirmed this observation.[13]

B. Experience with CO_2 Pipelines

Carbon dioxide suppliers, purchasers, and third parties that own existing CO_2 pipelines provide practical knowledge about how such pipelines operate. CO_2 pipelines are similar to natural gas pipelines, and they can transport CO_2 from its source to a sink. The primary difference between CO_2 and natural gas pipelines is that CO_2 pipelines require higher pressures (roughly 2,000 psi

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[11] *See* PCOR Partnership, *Plains CO2 Reduction (PCOR) Partnership (Phase I) Final Report/July–September 2005 Quarterly Report*, January 2006, *available at* http://gis.undeerc.org/website/PCORP/cdpdfs/FinalReport.pdf.

[12] EERC, Presentation, Potential Sequestration Options in the Plains CO2 Reduction (PCOR) Partnership Region & Estimated Capacities, Aug. 9, 2006 (on file with Excelsior Energy).

[13] Testimony of Edward N. Steadman, Oct. 10, 2006, MPUC Docket No. E-6472/M-05-1993, OAH Docket No. 12-2500-17260-2.

instead of 1,000 psi). Dedicated CO_2 pipelines are currently used for EOR in the Permian Basin and the Weyburn Oil Field. In the Kinder Morgan pipeline, which services the Permian Basin, 1 billion cubic feet per day of CO_2 is compressed from 800 to 2,000 psi and transported 500 miles.[14] Applying this knowledge, IGCC power stations will dry and compress carbon dioxide and inject it into pipelines. Over long pipeline distances, booster stations will periodically recompress the CO_2.

VI. Scenarios to Be Further Investigated

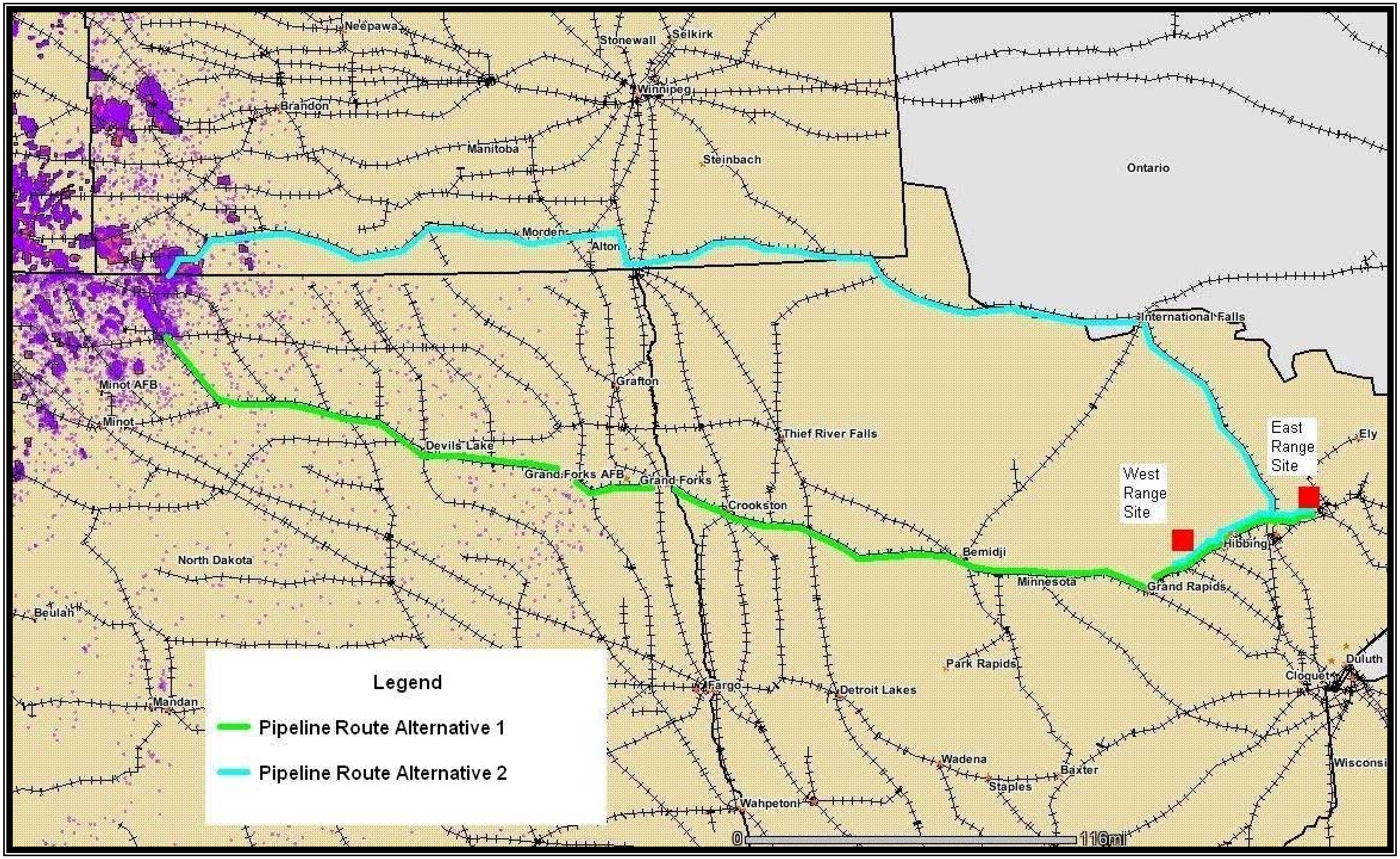
This section evaluates five CCS configurations associated with the Mesaba Energy Project in an effort to give policymakers further information about potential CCS options. CCS based on EOR alone will be examined for the 30% capture configuration, across one to six Mesaba Energy Project units (each unit is assumed to have roughly 600 megawatts of capacity). As discussed in Section IV, the 90% capture configuration is not yet commercially available. Therefore, although this may change in time, Excelsior does not assume 90% capture for the purpose of generating the economics in this CCS Plan. As a simplifying baseline assumption, this CCS Plan further assumes that cost-sharing opportunities with other CO_2 sources will not be available.

A. Scenario 1

For Scenario 1 and its alternatives, pipelines would be constructed between the three Mesaba Energy Project's Iron Range plant sites (each site containing two generating units) and a cluster of oil fields in north central North Dakota, the southwestern corner of Manitoba, and the southeastern corner of Saskatchewan. Many of these oil fields are either unitized or run by a single operator, which expedites the establishment of EOR in a field. (Unitization is a process by which field operators combine all oil and gas interests in a field into a single operation.) Non-unitized, multiple operator fields may take longer to set up EOR, so the readily available fields would be advantageous and the likely economic choice. For the main trunk pipeline connecting the plants and oil fields, two options for rights of way ("ROWs") are shown in Figure 1. The pipeline corridors in these scenarios follow existing rail ROWs only for the purpose of illustration – other potential corridors may exist.

[14] Kinder Morgan, Cortez Pipeline and McElmo Dome, http://www.kindermorgan.com/business/co2/transport_cortez.cfm.

Figure 1. Potential Pipeline Routes for the Mesaba Energy Project CO_2 Pipeline

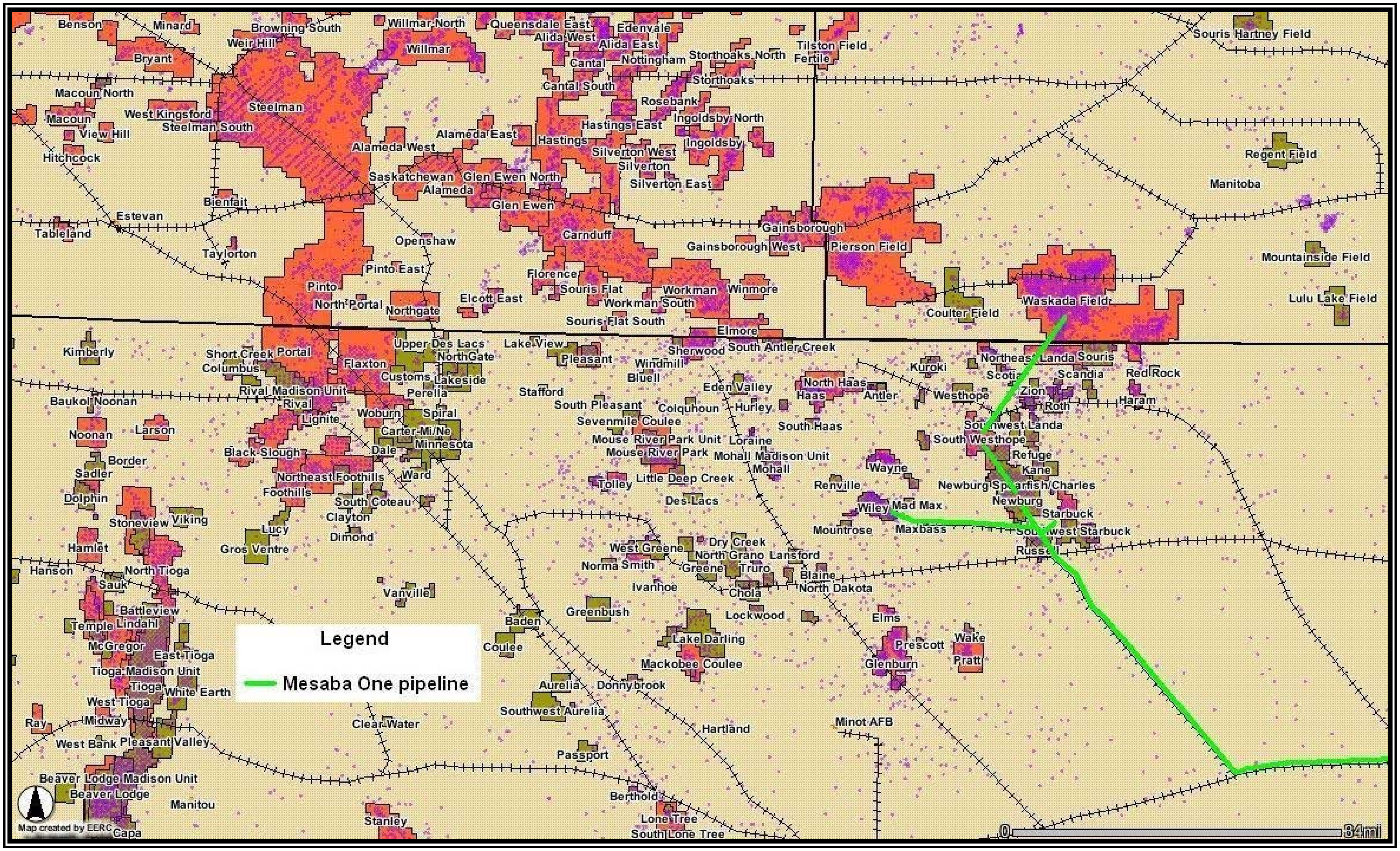


Source: EERC

B. Scenario 1A

For the CO_2 captured at Mesaba One, a cluster of oil fields in north-central North Dakota and southwestern Manitoba are targeted, with preliminary expectations that such fields could accommodate EOR for 22 years. This duration, which is used throughout the analysis of the various scenarios, corresponds to that of the financial model and does not reflect cessation of capture. Following existing railroad track (for purposes of illustration) from the preferred West Range site, a 12-inch pipeline approximately 405 miles long could reach the first proposed oil field. Over the course of 22 years, an additional 40 miles of pipeline would be needed to connect to nearby fields. Two of the fields are unitized. The pipeline network needed to serve this scenario is shown in Figure 2.

Figure 2. Western Terminus of CO_2 Pipeline Serving Mesaba One

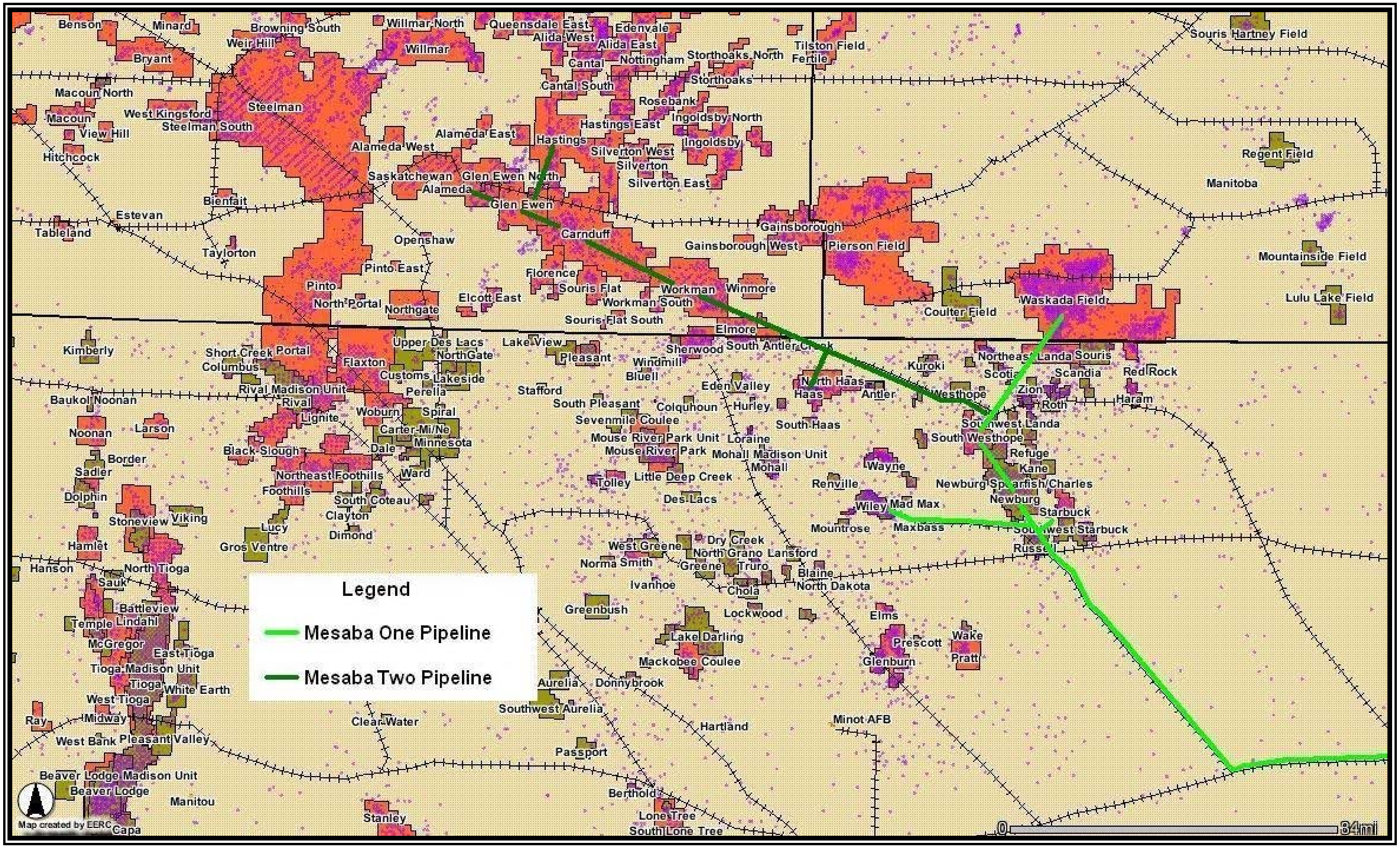


Source: EERC

C. Scenario 1B

For Mesaba One and Two, the network of pipelines would expand to a chain of oil fields in southeastern Saskatchewan. To accommodate 22 years of EOR from both units, approximately 120 additional miles of pipeline would be added for a total system length of 525 miles. This length is inclusive of additions required for a single unit as described above, and such additions could be staged. To illustrate the economies of scale, it will be assumed that the trunk pipeline is sized to accommodate two units, such that looping (i.e., duplicating) the 405 mile base pipeline is not necessary. The pipeline network for this scenario is shown in Figure 3.

Figure 3. Extension of Western Terminus of Mesaba One Pipeline to Accommodate Mesaba Two



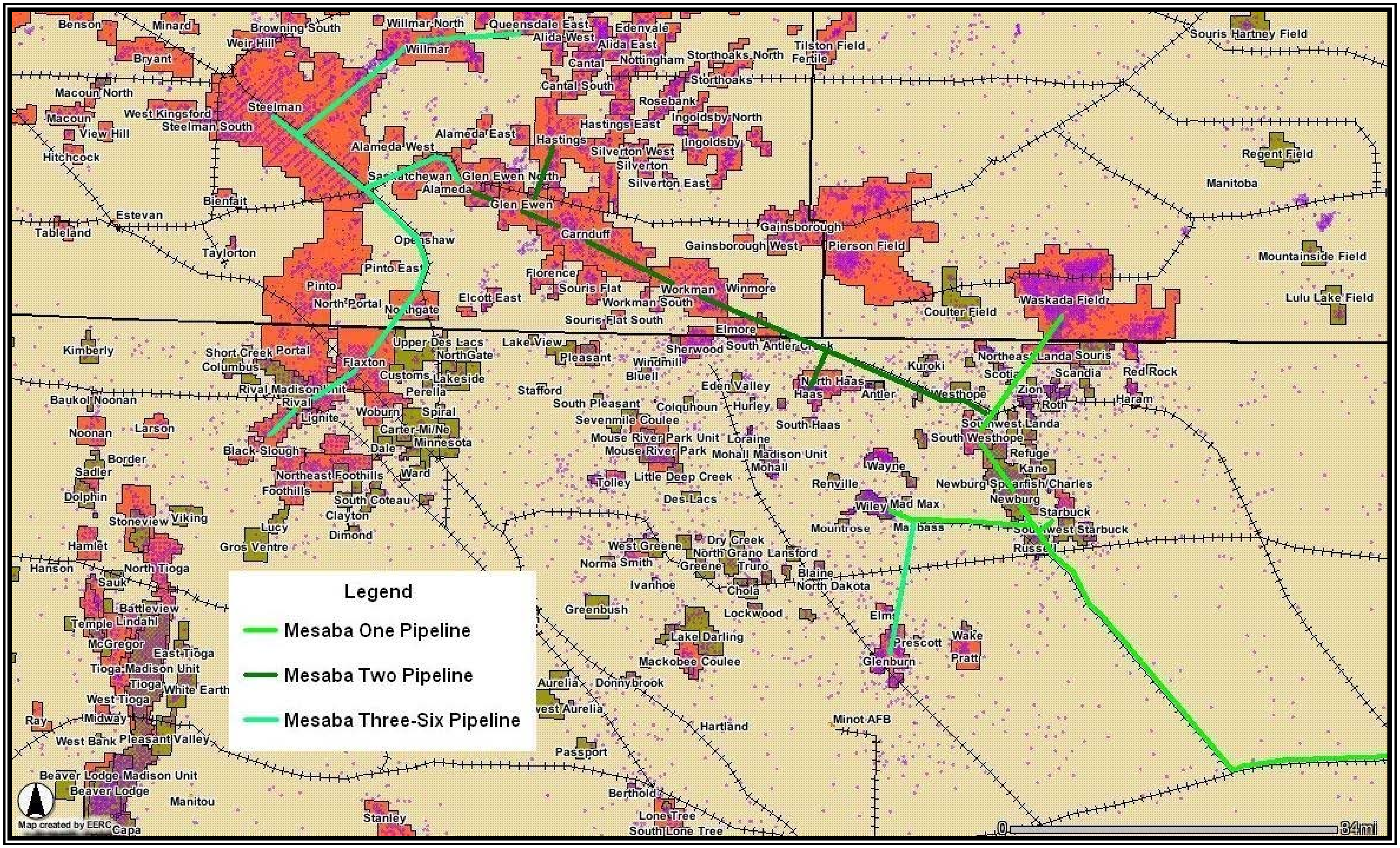
Source: EERC

D. Scenario 1C

For Mesaba Units One through Six, the pipeline network could reach much larger fields in Saskatchewan and North Dakota. The incremental pipeline additions for these units would include 85 new miles, for a total system length of 610 miles, as shown in Figure 4. While this scenario would be the most efficient and economical, the degree of uncertainty is too great to model even on a preliminary basis at this time. This scenario demonstrates that the potential for EOR present a CCS opportunity, and that a cost-shared pipeline accommodating multiple sources is a very promising means to defray the overall final costs of CCS.

The introduction of carbon credits or other benefits for reductions under mandated carbon constraints to these scenarios would improve the economics presented in the CCS Plan and would not otherwise intrinsically alter the ideal implementation of pipeline routes. Other sources may be induced to pursue EOR, but the relative cost competitiveness among those sources would not likely change.

Figure 4. Extension of Western Terminus of Pipeline to Accommodate Mesaba One Through Mesaba Six



Source: EERC

E. Scenario 2

Scenario 2 considers CCS based solely on carbon credit revenues or other benefits of CCS under carbon constraints, with the Mesaba Energy Project as the only source. In this case, CO_2 would only need to be piped approximately 265 miles from the West Range site to the Lower Cretaceous saline formation in eastern North Dakota.[15] Once again, existing right-of-way is shown for purposes of illustration. The EERC projects that the capacity of this saline formation dwarfs that of the oil fields considered in Scenario 1, so it is expected that the same pipeline route could serve all units at 30% or 90% capture.[16] The route in Scenario 2 is shown in Figure 5.

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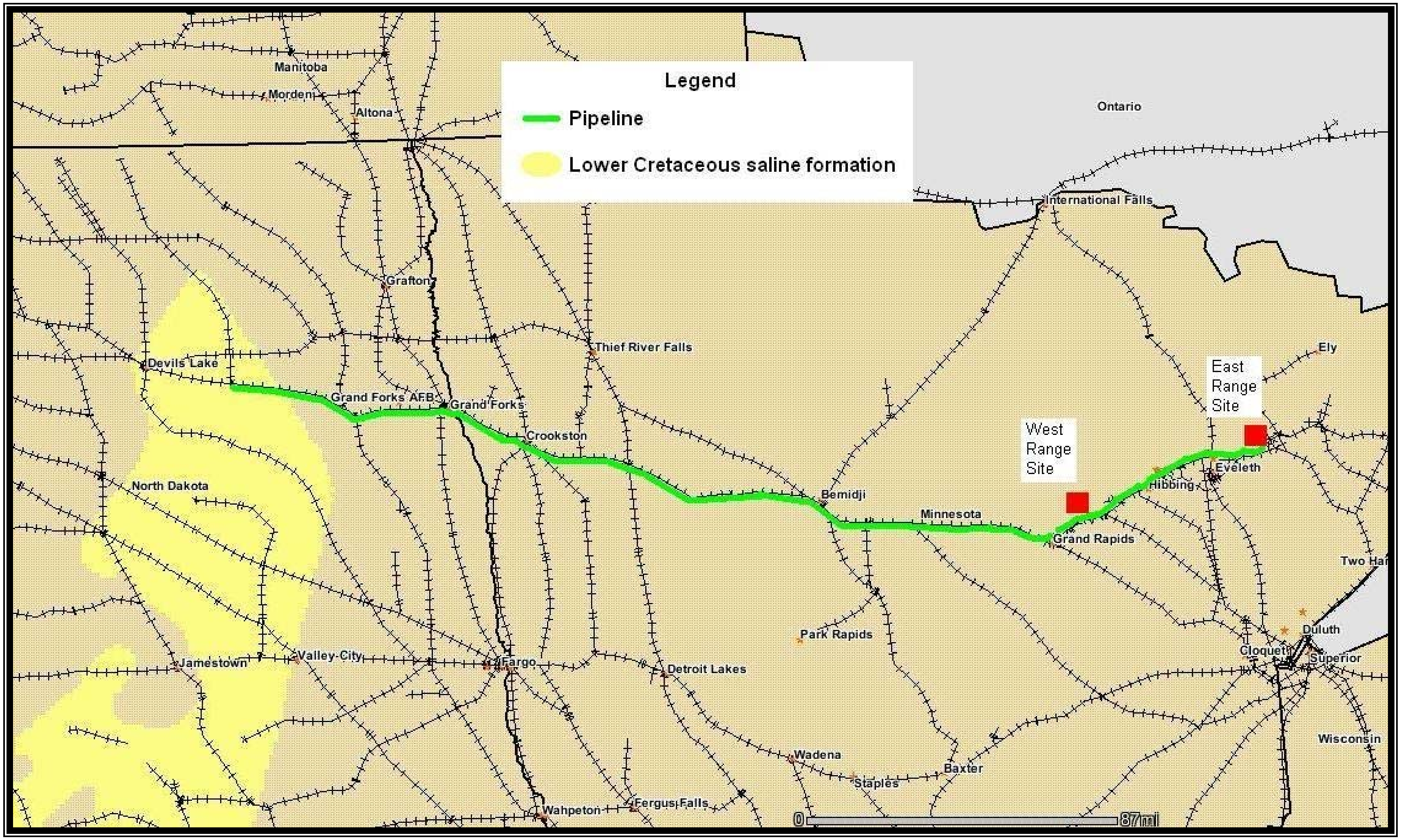
[15] See the Oct. 10, 2006 testimony of Edward N. Steadman, OAH Docket No. 12-2500-17260-2, MPUC Docket No. E-6472-/M-05-1993

[16] EERC, Presentation, Potential Sequestration Options in the Plains CO2 Reduction (PCOR) Partnership Region & Estimated Capacities, Aug. 9, 2006 (on file with Excelsior Energy).

Figure 5. CO_2 Pipeline to Saline Formations for Carbon Credits (No EOR)

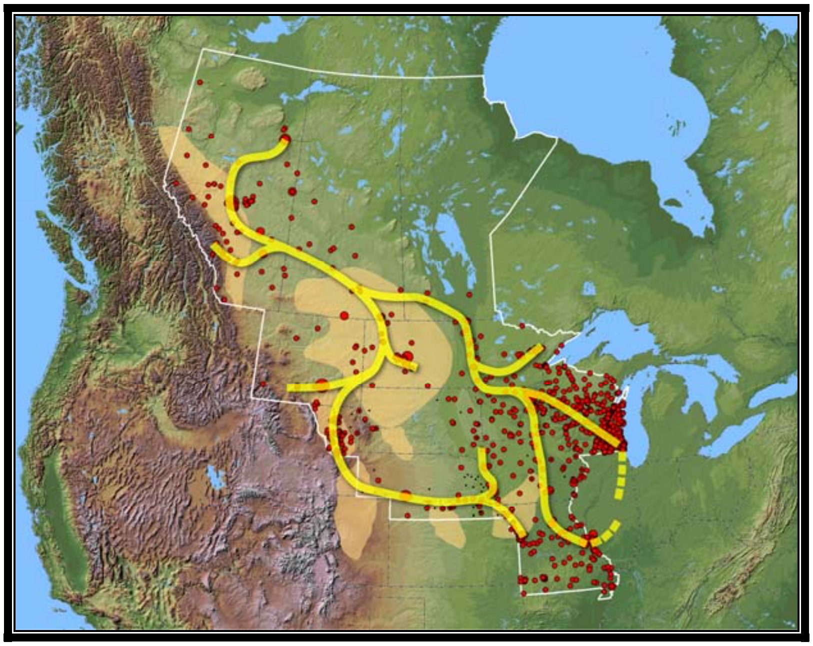


Source: EERC

E. Scenario 3

As Scenario 1C begins to demonstrate, the economies of scale for CO_2 transport could be significant. In a fully implemented GHG regulatory scheme, it would be conceivable that the majority of large industrial facilities (epitomized by large electric generation facilities) would be capturing CO_2. The EERC's vision for a major pipeline system serving the PCOR region is laid out in Figure 6. As the map shows, the concentration of industry on the Iron Range makes it a likely route for a major artery of the CO_2 network.

Figure 6. EERC's Vision of CCS in a Carbon Managed Economy



Source: EERC

VII. Preliminary Economic Analysis

Excelsior used the Mesaba Energy Project's proprietary financial model to identify the breakeven value of CO_2 (in 2006$ per ton) captured in the 30% approach for each scenario identified in Section VI. This modeling is preliminary in nature and is intended to i) illustrate economic dependencies around important CCS Plan variables rather than absolute costs and ii) determine whether a more thorough investigation is justified. All cases assumed that capital outlays associated with CCS occur in 2011, and that CO_2 capture commences in the third quarter of 2014 and continues for 22 years (through the duration of the financial model).

The financing structure and economic assumptions used in the modeling of these carbon capture scenarios are consistent with Excelsior's assumptions in its current financial model used to evaluate the Mesaba Energy Project. The cases are modeled to recover the costs associated with the CCS program and maintain the required return to the projects equity investors. The effects of the sensitivities shown below are displayed as changes in NPV from a base case and are calculated using an 8% discount rate. Estimates for the cost of 90% removal are not available, so only 30% capture was modeled.

Fluor developed an estimate for the cost of the 30% capture configuration,[17] and Excelsior integrated that estimate into the Mesaba Energy Project's financial model. There are two main economic impacts associated with carbon capture: equipment capital cost and reduced plant capacity, which also causes an increase in plant heat rate. The equipment includes the amine stripper and the CO_2 drier and compressor. Plant capacity is reduced and heat rate is increased because these processes are steam driven, and because the CO_2 would need to be replaced by steam as a diluent for NO_x control. In an attempt to determine if CCS can be accomplished without additional costs to utility ratepayers, the cost of fuel increase on a megawatt-hour (MWh) basis corresponding to the heat rate increase was attributed and charged to the CCS project in the model assumptions. Total capital cost additions are currently estimated to be [**BEGIN TRADE SECRET: END TRADE SECRET**] and the anticipated increased O&M costs for that equipment is [**BEGIN TRADE SECRET: END TRADE SECRET**]. The capacity reduction for the IGCC Power Station is currently estimated to be [**BEGIN TRADE SECRET: END TRADE SECRET**], with the increased heat rate expected to be [**BEGIN TRADE SECRET: END TRADE SECRET**].

As for pipeline cost estimates, the Dakota Gasification Project's ("DGP") CO_2 pipeline to the Weyburn oil field was used as the basis for estimating costs. The DGP pipeline was built for $120 million in 1997, and consisted of 204 miles of nominal 12" and 14" Schedule 40 pipeline.[18] Conservatively assuming it was all 12" pipeline and escalated to 2005 dollars, the total cost for a CO_2 pipeline in the Northern Plains is assumed to be $60,920 per inch-mile. Based on the design capacity of the Weyburn pipeline, a nominal 12" Schedule 40 pipeline is sufficient to transport CO_2 produced by 30% capture at Mesaba One, with the Mesaba One and Two units requiring a 14" pipeline. A further conservative assumption utilized in the analysis is that the total pipeline network is built up front. Costs could be reduced by deferring network expansions to additional oil fields

Excelsior Energy modeled Scenarios 1A, 1B, and 2, and the results are presented in Table 2. For Scenarios 1A and 1B, revenues could be earned from both EOR and carbon credits sales (or through other carbon reduction benefits to ratepayers when constraints are imposed). This data illustrates that the economies of scale are important for CCS – the required price per ton drops significantly with larger volumes of CCS, despite the fact that 80 additional miles and an increased diameter for the pipeline would be necessary. Scenario 2 demonstrates that the Mesaba Energy Project could capture and sequester carbon at an even lower overall cost, although such capture could not reap EOR revenues. As explained above, these cost estimates are illustrative rather than predictive, and conclusions should be limited accordingly. The accuracy of these estimates must be refined by additional study before the economic viability of the project can be judged.

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[17] Fluor Enterprises, Inc., *Mesaba Energy Project Partial Carbon Dioxide Capture Case*, October 2006, attached as Exhibit DC __ (DC-7) to the Oct. 10, 2006 testimony of Douglas H. Cortez, OAH Docket No. 12-2500-17260-2, MPUC Docket No. E-6472/M-05-1993.

[18] See p. 857 of Kovschek, A. R. *Screening Criteria for CO2 Storage in Reservoirs*, Petroleum Science and Technology, 2002. Vol. 20, No. 7&8, pp. 841-866. Also, see Dakota Gasification Company, *available at* http://www.dakotagas.com/SafetyHealth/Pipeline_Information.html.

Table 2. Cost of Captured CO_2

	EOR	Pipeline length	Total CCS Cost ($/ton)
Scenario 1A	Yes	445 miles	$40
Scenario 1B	Yes	525 miles	$35
Scenario 2	No	265 miles	$32

Due to the high degree of uncertainty in many of the important assumptions, Excelsior conducted a sensitivity analysis. Scenario 1A was used as the base case for this analysis, and the results are shown in Table 3. Pipeline costs represent the greatest source of uncertainty, both in terms of the uncertainty of the cost assumed and impact that assumption has on total project cost. It is crucial that the range of this cost be narrowed, and the engineering studies proposed in Section I would address these and other issues. While the effect of capacity loss is nearly as material to the analysis, there is greater modeling certainty in the assumed values.

Table 3. Sensitivity Analysis of CCS Costs

Factor	Case	Input Value Assumed	Required CO2 Value/Total CCS Cost
Pipeline Cost	Low	$30,145/in-mi	$30/ton CO_2
	Base	$60,290/in-mi	$40/ton CO_2
	High	$90,435/in-mi	$50/ton CO_2
Plant Capital	Low	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
	Base	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
	High	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
Capacity/ Heat Rate	Low	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
	Base	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
	High	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
Plant O&M	Low	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
	Base	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
	High	[**BEGIN TRADE SECRET:**	**END TRADE SECRET**]
Pipeline O&M	Low	$890/mi-yr	$40/ton CO_2
	Base	$1,780/mi-yr	$40/ton CO_2
	High	$2,760/mi-yr	$41/ton CO_2

It is important to note that the greatest uncertainty surrounding the economics of a CCS project is revenue, as EOR depends upon volatile oil prices and carbon credit prices (or other economic benefits from reductions under carbon constraints) depend upon future regulation. However, such uncertainties are not specific to the Mesaba Energy Project and must be overcome by any major undertaking of CCS. The figures presented in the remainder of this section elaborate upon the modeled impact of CO_2 prices on the net present value of different scenarios in the CCS Plan.

Figure 7 shows the impact that the value of CO_2 has on project economics. This value for CO_2 is derived from either EOR or a combination of EOR and carbon credits or other CCS regulatory benefits, and corresponds to Scenario 1A with the baseline assumptions described above. Similarly, Figure 8 examines this impact if revenues are from carbon credits exclusively (that is, no EOR). CO_2 would be sequestered in saline formations, corresponding to Scenario 2. Thus, for Figure 8 the impact to the NPV is based on Scenario 2's $32/ton case as the $0 NPV reference.

Figure 7. Sensitivity to Changes in Total CO_2 Revenue ($/ton CO_2) in Scenario 1A

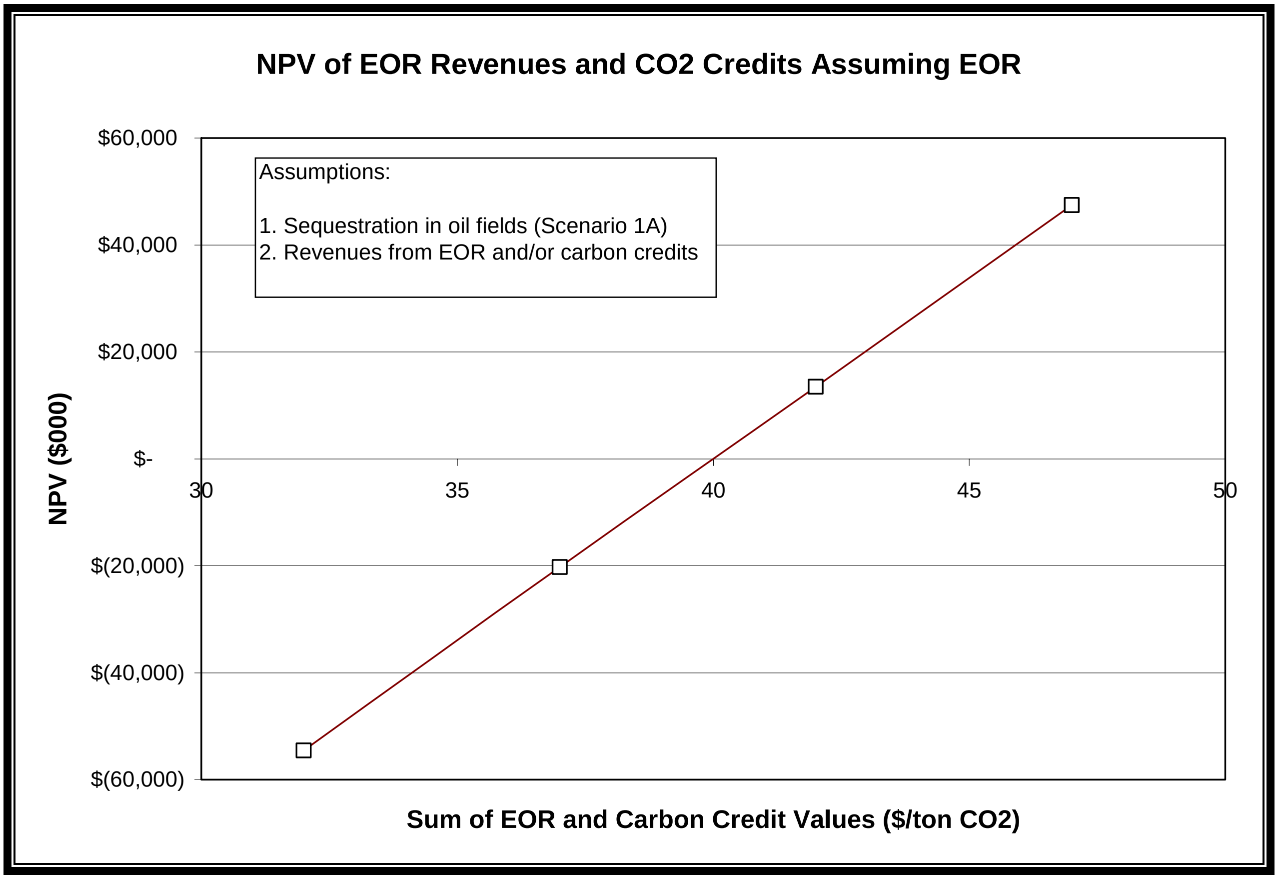
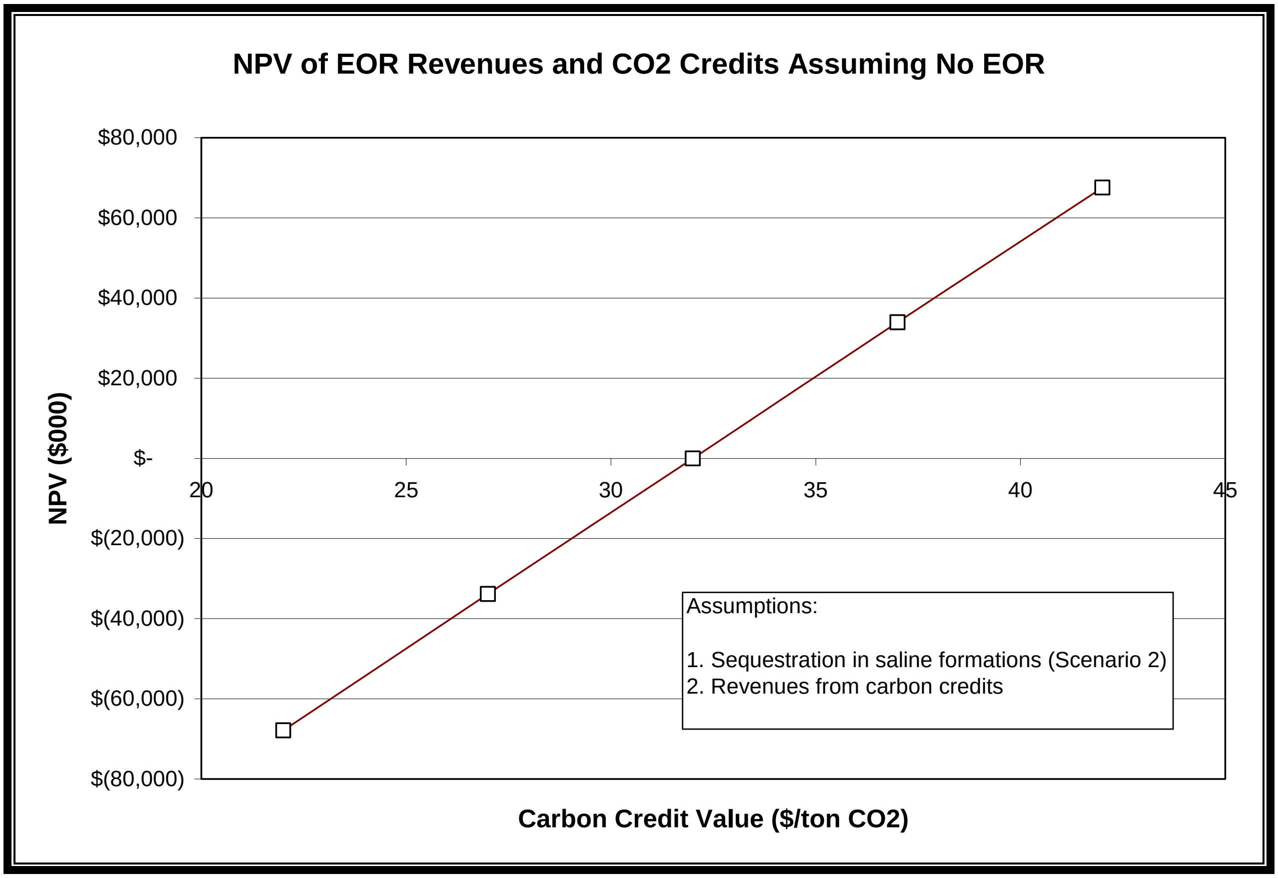
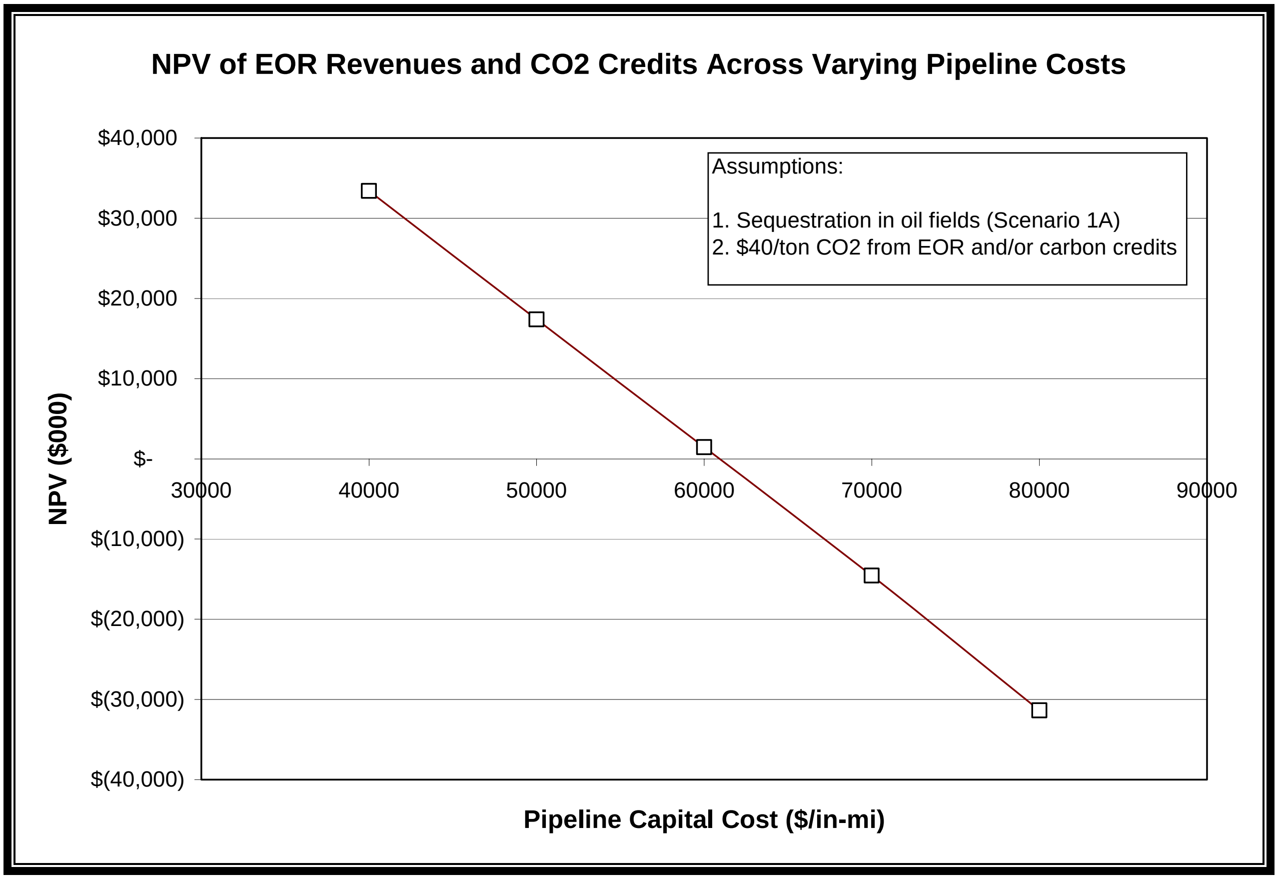


Figure 8. Sensitivity to Changes in Carbon Credit Revenue ($/ton CO_2) in Scenario 2



Changes in the NPV of different scenarios in the CCS Plan due to changes in pipeline costs are shown in Figure 9. This figure assumes that the total value of CO_2 will average $40/ton.

Figure 9. Sensitivity to Changes in Pipeline Costs ($/in-mi) in Scenario 1A



Carbon credits are currently trading at approximately $17/ton in Europe.[19] The value of CO_2 for EOR is highly variable according to oil prices, specific field geology, and source competition. At oil prices of $15–20/bbl, CO_2 can be worth $10–16/ton for EOR, and more at higher prices of oil.[20] As carbon regulations are introduced and become stricter, and as the price of oil increases, the price of CO_2 can be expected to rise. Although it is premature to conclude whether CCS in any scenario presented here is economical, Excelsior believes that additional study towards that end is warranted.

The alternative sources of CO_2 for EOR in the fields identified in Scenario 1 are limited. The largest of these by far are conventional coal plants in the region, but post-combustion CO_2 capture for such sources has only been demonstrated at pilot scale. The cost per ton is expected to be higher for conventional coal than for the Mesaba Energy Project, even if a much shorter pipeline is assumed for the former.[21] Ethanol plants and natural gas processing facilities are able

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[19] The market closing price on October 18 was €12.90 (http://www.pointcarbon.com), which is equivalent to $16.25 USD.
[20] Intergovernmental Panel on Climate Change, IPCC Special Report: Carbon Dioxide Capture and Storage, p. 33 (2005), *available at* http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/ccsspm.pdf.
[21] See Ref. 2.

to produce CO_2 at a much lower cost than conventional coal plants, but lack the capacity to saturate the EOR market. Fields along the pipeline built by the Dakota Gasification Project can accommodate its supply for decades to come. Therefore, it is reasonable to expect that EOR revenues could be available to the Mesaba Energy Project across the time frames proposed.

Excelsior assumes that it will be positioned to obtain partial DOE cost sharing for construction of the CO_2 pipeline. However, irrespective of such funding potential, Excelsior believes it is in the interests of the both the Mesaba Project and the state to better understand the economic drivers for CCS programs and the need to firm up equipment/construction costs at the plant, along the pipeline route, and at the oil fields. Detailed engineering studies conducted under carefully defined scopes of work will help refine such costs.

The EERC, in conjunction with Excelsior, will develop CO_2 management options for the Mesaba Energy Project based on evaluations of sequestration opportunities associated with regional geologic formations/features and nearby terrestrial features. The study will match carbon sinks to the Mesaba Project and rank the sinks according to engineering, economic, and public-acceptance considerations. The schedule calls for the EERC to complete an analysis of the identified CO_2 management options in December 2006. Excelsior will use the results of this analysis to narrow the scope of its Phase III proposal to the DOE for demonstrating the commercial readiness of carbon sequestration via IGCC.

In preparing the Phase III proposal, the EERC and Excelsior will formulate best practices required to accomplish sequestration of CO2 from IGCC facilities and publish the results as part of a manual that can be used by others undertaking IGCC projects.

VIII. Summary and Conclusions

Excelsior has prepared this CCS Plan to offer the Commission and Minnesota ratepayers options to capture and sequester a significant portion of the CO_2 emissions from the Mesaba Energy Project. Based on the scientific and technical considerations, marketplace and operating assumptions, the financial analyses, and future carbon regulations assumed in this CCS Plan, Excelsior anticipates that future technical studies will verify that it will be feasible to capture and sequester CO_2 emissions from the Mesaba Energy Project. As explained in the CCS Plan, the most promising CCS scenario is for Excelsior to transport its CO_2 via high-pressure pipelines to the depleted oil fields associated in the Williston Basin located in North Dakota, southwestern Manitoba, and southeastern Saskatchewan.

This CCS Plan reflects the work undertaken to date by Excelsior and the PCOR initiative. Significant work remains to refine the engineering and economic information it contains. This work will be advanced by the PCOR initiative. Excelsior will continue to update this information as its work with PCOR progresses. Excelsior would be amenable to exploring a commitment with the Commission to apply the final $2 million of its RDF award to further efforts to refine this plan. If feasible from the Commission's perspective, Excelsior would propose to accelerate the funding of that amount in order to facilitate a more rapid completion of a detailed engineering plan and cost proposal for CCS. Excelsior anticipates that such a detailed plan could be developed within a year from the date such funding is made available. The CCS Plan could also serve as the foundation for a competitive proposal in response to the Department of Energy's ("DOE") planned Phase III solicitation for demonstrating full scale CCS projects. Accelerating development of a very detailed plan would enhance Minnesota and the Mesaba Project's prospects to obtain federal matching funds under DOE programs.

It is in the long-term interests of the state to proceed expeditiously with the development of feasible CCS options. Excelsior looks forward to working with regulators, stakeholders, and industry participants to provide the important hedge to Minnesota consumers offered by the timely development of carbon capture and sequestration.

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APPENDIX A2
DOE Analysis of Feasibility of Carbon Capture and Sequestration for the Mesaba Energy Project

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APPENDIX A2
DOE ANALYSIS OF FEASIBILITY OF CARBON CAPTURE AND SEQUESTRATION FOR THE MESABA ENERGY PROJECT

This section discusses carbon capture and sequestration (CCS) and examines why it is not commercially feasible for the proposed action. The discussion includes consideration of the technical and economic feasibility of CCS given current and expected state-of-the-art technologies, foreseeable developments, market forces, and the regulatory framework in relation to the expected in-service date of the project.

The Mesaba Energy Project was selected in 2004 under the Clean Coal Power Initiative (CCPI) Round 2 Funding Opportunity Announcement. CCS was not a requirement of the Round 2 announcement, was not proposed in Excelsior's application submitted in response to the announcement, nor is it included within the project as negotiated and awarded in the DOE Cooperative Agreement. CCS will be the focus of the future CCPI Round 3 Funding Opportunity Announcement.

DOE has parallel research programs aimed at reducing the cost of electricity associated with power production and proving the technical viability of CCS technology. Advancements in gasification, turbine, and CCS technology must converge to make CCS technically and economically feasible. Projects like Mesaba will advance the state-of-the-art in gasification technology thereby making CCS more likely to be deployed in the future.

DOE expects that the combined efforts of these programs will enable large-scale plants to come on-line by 2020 that offer 90% carbon capture with 99% storage permanence at less than a 10% increase in the cost of energy services[1]. The planned in-service date for the Mesaba Energy Project is well in advance of the timeline for achieving the DOE goal.

<u>Technical Feasibility of Carbon Capture</u>

As discussed in Section 2.2.1.3, Section 5.1.2, and Appendix A1, Excelsior has presented a multiple-option carbon management plan to the Minnesota Public Utilities Commission (PUC). At its baseline, the Mesaba Energy Project would be designed with sufficient space available in its footprint for future installation of carbon capture equipment. Adjacent systems would also be designed to facilitate modification for interfacing the carbon capture equipment.

The plan includes the option of using commercially available amine scrubbers to remove carbon dioxide from the syngas stream prior to combustion in the gas turbines that would, assuming 100% subbituminous coal input, result in a nominal 30% reduction in overall carbon dioxide emissions from the plant. Incorporation of this base case carbon capture scenario would result in an adverse impact to plant efficiency and the price of electricity. Other commercially available capture technologies, such as Selexol® and Rectisol® would have a greater adverse impact on plant efficiency and the price of electricity[2].

Excelsior's carbon management plan for the Mesaba Energy Project includes an additional option to convert the carbon monoxide present in the syngas to carbon dioxide for greater removal, if future conditions justified this option. This could conceivably result in about a 90% reduction in overall carbon dioxide emissions from the plant. However, the technologies required for this rely on a gas turbine that is capable of running on hydrogen-rich gas. For example, this process relies on converting water and carbon monoxide to carbon dioxide and hydrogen, as shown in the reaction below, using a water-gas shift reactor.

$$CO + H_2O \rightarrow CO_2 + H_2$$

This results in a carbon monoxide-depleted, hydrogen-rich syngas. Conventional, commercially available combustion gas turbines envisioned for this project cannot operate on carbon monoxide-depleted syngas where the hydrogen concentration approaches 100%. Currently commercially-available combustion gas turbines at sizes much smaller than those envisioned for this project operate on hydrogen-rich fuels. These machines are typically operating on a blend of hydrogen (typically less than 60% hydrogen) and some other energy containing fuel, such as carbon monoxide or methane. However, the size, combustion technology and vintage of these smaller and older machines results in poor performance in terms of low efficiency and high emissions. This current experience, on smaller machines fueled with a hydrogen blend, does not translate to technology for larger machines fueled with nearly 100% hydrogen that would be needed for the Mesaba project, where high efficiency and low emissions are a requirement.

Currently, advanced turbines are in development that address these issues but are not expected to be commercially available at the Mesaba project's in-service date. Even when these advanced turbines are commercially available, the option of precombustion decarbonization to produce a hydrogen fuel would result in substantial capital cost, reduce overall plant efficiency and adversely impact the price of electricity from the Mesaba project. Testimony sponsored by Excelsior in the PUC docket estimated that under the 90% removal scenario, capital equipment cost could increase by up to 40%; corresponding increases in the net plant heat rate would approach 21%[3]. Other independent estimates are that the addition of 90% capture technologies to a gasification plant would increase the cost of energy by about 17%[4] and decrease the net power plant efficiency by about 6-9%[5].

<u>Technical Feasibility of Carbon Dioxide Transport</u>

There are no sufficiently characterized geologic reservoirs capable of sequestering carbon dioxide within the state of Minnesota. The nearest geologic formation of potential interest would be the Lower Cretaceous saline formation approximately 265 miles from the proposed West Range Site. The nearest formation with the potential for revenues would be associated with enhanced oil recovery (EOR) in the Williston Basin of North Dakota. Both scenarios would require a pressurized pipeline; such a pipeline would need to extend at least 400 miles to reach the Williston Basin. Much experience has been gained in the design, construction and operation of pipelines for transport of carbon dioxide for EOR. There are about 3,000 miles of existing carbon dioxide pipeline in the United States, including examples of pipelines up to 500 miles in length. It is therefore technically feasible to build a pipeline to oil fields or other sequestration sites within about 500 miles from the Mesaba Energy Project location. However, assuming rights-of-way, permits and off-take agreements could be obtained, the cost associated with the transport would significantly increase the cost of electricity.

Technical Feasibility of Carbon Sequestration

Sequestration options include suitable EOR and injection into compatible geologic formations. Beneficial reuse, such as carbonation for soda pop, does not constitute sequestration because it ultimately results in release to the atmosphere. Sequestration is the subject of a great deal of research relative to the efficacy of long-term storage (i.e., permanence) and characterizing suitable “carbon sinks” to ensure that any potential adverse environmental impacts are understood and minimized. DOE has created a network of seven Regional Carbon Sequestration Partnerships to develop the technology, infrastructure, and regulatory framework necessary to implement carbon sequestration in different regions of the Nation. Planning for large-scale sequestration tests is scheduled to begin in fiscal year (FY) 2008 and the tests would run through FY 2017. The purpose of the tests is to demonstrate that large quantities (e.g. one million tons of carbon dioxide per year) can be transported, injected, and stored safely, permanently, and economically.[1]

Large-scale and long-term commercial application of carbon dioxide injection for EOR has occurred in the Texas Permian Basin and in the Weyburn field of the Williston Basin. However, these are economically-driven operations to increase oil production not necessarily scientifically-driven to prove the technical feasibility of permanently sequestering carbon.

Therefore, the technical feasibility of carbon sequestration for the Mesaba Energy Project cannot be validated in the near-term until extensive field tests are conducted to fully characterize potential storage sites and the long-term storage of sequestered carbon has been demonstrated and verified. Further, an MIT study[4] concluded that the major uncertainties surrounding geologic sequestration should be resolved within 10-15 years, which is consistent with the DOE Carbon Sequestration Program goal.

Economic Feasibility of Carbon Capture and Sequestration

The effect of CCS on the cost of electricity from the Mesaba Energy Project has not been quantified. However, there have been a number of studies of the costs of CCS for IGCC plants that show the costs of CCS could increase the cost of electricity by as much as 40%,[6] depending on assumptions regarding the value of the carbon dioxide produced. No statutory or regulatory requirement exists for CCS. Nor does a viable market currently exist for carbon credits. Environmental and construction permitting associated with transport and sequestration would significantly delay the project, further increasing the cost of electricity. Even if the carbon dioxide could be sold for EOR operations, the revenues from carbon dioxide (estimated at about $20 per ton) would be grossly insufficient to recover such costs. Hence, imposition of CCS on the project will effectively make the cost of electricity non-competitive.

Summary Conclusion

Carbon capture and sequestration is not considered feasible for the Mesaba Energy Project at this time. However, the carbon management plan for the Mesaba Energy Project is a logical starting point from which the PUC can derive findings and thereby establish the appropriate timing and price at which carbon capture and sequestration becomes in the Minnesota ratepayers' interest. Without an order from the PUC that incorporates the costs associated with CCS within the power purchase agreement, the Mesaba Energy Project would not be economically viable.

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