414 Nicollet Mall
Minneapolis, MN 55401

PUBLIC DOCUMENT
TRADE SECRET DATA EXCISED

September 23, 2009

- VIA E-MAIL & U.S. MAIL -

Darrell Nitschke,
Director of Administration and Executive Secretary
North Dakota Public Service Commission
State Capitol Building, Dept. 408
600 East Boulevard
Bismarck, ND 58505-0480

Re: APPLICATION OF NORTHERN STATES POWER COMPANY, A MINNESOTA CORPORATION, FOR AN ADVANCED DETERMINATION OF PRUDENCE FOR THE 20 MW BAY FRONT PROJECT

Dear Mr. Nitschke:

Northern States Power Company, a Minnesota corporation ("Xcel Energy" or the "Company"), is pleased to offer this Application for an Advanced Determination of Prudence ("ADP") for our proposed 20 megawatt ("MW") Bay Front Project located in Northern Wisconsin. The purpose of this ADP filing is to provide the Commission with information about this proposed Project. While the size of this facility falls below the commitment threshold for an ADP filing established in our recent rate case settlement, this filing is part of our on-going efforts to fully inform the Commission of facilities that will affect electric rates for our North Dakota customers in the future.

The Project will consist of installing a biomass gasification system to convert waste wood to synthetic gas ("syngas") and modifying the existing boiler #5 at Bay Front to burn the gas effectively to produce steam for electric power generation. In addition, we will increase the biomass receiving, storage and handling capabilities and add enhanced flue gas filtering equipment to capture residual particulates.

After receiving all necessary approvals for this Project, we anticipate we will begin engineering and procurement in 2010. Primary construction is planned to begin no later than mid- 2011 with commercial operation targeted for October 2012.

The Bay Front Project provides a unique opportunity to utilize an existing generating site and infrastructure, take advantage of gasification technology, and increase the use

of the indigenous fuel source of northwestern Wisconsin to cost effectively meet the needs of our electric customers. Comparative analyses confirm the Project's costs are reasonable and will have a minimal impact on customers' bills. In addition, the Project is a dispatchable, high capacity factor, and renewable resource that will displace the use of coal and natural gas, thereby reducing emissions and the risk of market volatility.

Included with this application is our filing fee of $125,000 and my signed affidavit supporting the truthfulness of our statements. A Non-Public version of the filing is being submitted under separate cover.

We look forward to working with the Commission in the review of this filing and respectfully request that the Commission make a determination that the Bay Front Project meets the Advance Determination of Prudence requirement of NDCC Section 49-05-16.

SINCERELY,

/S/

JAMES R. ALDERS
DIRECTOR, REGULATORY ADMINISTRATION

Enclosures

STATE OF NORTH DAKOTA
BEFORE THE
PUBLIC SERVICE COMMISSION

IN THE MATTER OF THE APPLICATION OF NORTHERN STATES POWER COMPANY, A MINNESOTA CORPORATION, For ADVANCE DETERMINATION OF PRUDENCE FOR THE BAY FRONT BIOMASS GASIFICATION PROJECT	))))	**CASE NO. PU-_____**

AFFIDAVIT OF
James R. Alders

I, the undersigned, being first duly sworn, on oath depose and say that I am Director of Regulatory Administration for Northern States Power Company, a Minnesota corporation (the "Company") operating in North Dakota, and the applicant herein; that I have read the foregoing request For Advance Determination of Prudence for the Bay Front Biomass Gasification Project and that I believe all statements therein to be true and correct; and that said filing is submitted and signed on behalf of said Company with the consent and authority of the Company.

James R. Alders

Subscribed and sworn to before me, this 23rd day of September 2009.

Notary Public

CYNTHIA D HARRINGTON
NOTARY PUBLIC - MINNESOTA
My Commission Expires Jan. 31, 2010

PUBLIC DOCUMENT
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STATE OF NORTH DAKOTA
BEFORE THE
NORTH DAKOTA PUBLIC SERVICE COMMISSION

NORTHERN STATES POWER COMPANY,
A MINNESOTA CORPORATION

CASE NO. PU-_____

IN THE MATTER OF AN APPLICATION
FOR ADVANCE DETERMINATION OF
PRUDENCE FOR THE BAY FRONT
BIOMASS GASIFICATION PROJECT

INTRODUCTION

Northern States Power Company, a Minnesota Corporation operating in North Dakota ("NSP-M" or the "Company"), respectfully submits to the North Dakota Public Service Commission (the "Commission") this Application for an Advance Determination of Prudence ("ADP") pursuant to North Dakota Century Code ("NDCC") Section 49-05-16. This ADP application is for a proposed Biomass Gasification Project at the Bay Front Plant in northwestern Wisconsin ("Bay Front Project" or "Project").

The Bay Front Plant is owned by Northern States Power Company, a Wisconsin Corporation ("NSP-W"), and a portion of the costs of the Project will be shared with the Company through the Federal Energy Regulatory Commission ("FERC") approved Interchange Agreement,[1] and ultimately allocated to the North Dakota jurisdiction.

[1] NSP-W and NSP-M plan and operate their electric production and transmission systems on an integrated basis to affect the most economical and reliable supply of energy to meet their combined electric load. This integrated system is commonly referred to as the "NSP System", and NSP-M and NSP-W are collectively referred to as the "Xcel Energy Companies" or simply "Xcel Energy." Because of the integrated nature of their systems, the Company and NSP-W entered into an agreement for the sharing of all costs of generating and transmission facilities, including capital costs. This agreement is generally referred to as the Interchange Agreement, which was filed with and approved by the Federal Energy Regulatory Commission.

OVERVIEW

The purpose of this ADP filing is to seek the Commission's determination that our investment in the proposed Bay Front Project is prudent. This filing is part of the Company's on-going efforts to fully inform and engage the Commission in resource planning decisions that will affect electric rates for North Dakota customers in the future.[2]

The Project consists of:

1) retrofitting the existing Boiler #5 at Bay Front in Ashland, Wisconsin with state of the art biomass gasification technology; and
2) other improvements to convert Boiler #5's fuel source from coal and petroleum coke to biomass.[3]

Considering the investments necessary to comply with emerging air quality requirements for Boiler #5 and the increasing costs for the type of solid fuel mix that must be used in the existing boiler, Xcel Energy concluded that continuing to operate the facility using the current fuel mix of coal and petroleum coke would not be economic. The location and configuration of the Bay Front facility provides a unique opportunity to utilize existing generating infrastructure, take advantage of state of the art technology, and increase the use of a homegrown solid fuel source at a reasonable cost.

The conversion of Bay Front Boiler #5 to Biomass satisfies the ADP standards for the following reasons:

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[2] In the recent rate case settlement (Case No. PU-07-776, *Order Adopting Settlement*, Dec. 31, 2008), the Company committed to make an ADP filing for any capacity acquisition on the NSP System of at least 50 MW. While the Bay Front Project is smaller than this commitment, because of its significance as an energy investment we believe that it is appropriate to file this project for the Commission's ADP consideration.

[3]. Once completed, Boiler #5's biomass fuel source will consist of a variety of woody biomass sources primarily within northern Wisconsin, eastern Minnesota and the western edge of Michigan's Upper Peninsula including mill and harvest residues and other economically available biomass material.

- *The Project maintains a baseload resource.* The Bay Front Project is a baseload, dispatchable resource that will operate at a high capacity factor. The project will maintain an existing baseload resource on the NSP system, allowing the resource to operate for many years to come.

- *The Project is a cost effective biomass resource.* The conversion of Boiler # 5 at Bay Front provides a unique opportunity to utilize the existing plant site and infrastructure, minimizing costs while adding state-of-the-art biomass gasification technology to our system.

- *The Project is reasonable when compared to alternatives.* Several options for replacing the electricity other than the gasification proposal were considered. The Project compares favorably to all of these options. Additionally, by using a solid fuel supply that will be obtained locally, the Project provides a hedge against a potentially volatile fossil fuel market.

For all of these reasons, we believe that the Project is prudent and in the best interest of customers throughout the NSP system.

The remainder of this application is organized into the following sections:

- Description of the Applicant
- Request for an ADP
- Description of the Bay Front Project
- Assessment of Prudence and Reasonableness
- Communications and Service List

DESCRIPTION OF THE APPLICANT

NSP-M is a Minnesota corporation duly authorized to conduct business in the State of North Dakota as a public utility subject to the jurisdiction and regulation of the Commission pursuant to Title 49 of the NDCC. The full name and address of the Company is:

Northern States Power Company,
a Minnesota corporation
414 Nicollet Mall
Minneapolis, Minnesota 55401

The Company also operates in North Dakota from the following address:

Northern States Power Company
2302 Great Northern Drive
Fargo, ND 58102

NSP-M's Certificate of Incorporation and amendments were filed with the Commission on May 31, 2001 and are incorporated herein by reference.

NSP-M has service territory in three upper Midwest states including North Dakota. The Company presently serves approximately 87,000 retail electric customers in and around Fargo, Grand Forks, and Minot, North Dakota. NSP-M owns approximately 250 miles of transmission lines and 12 substations in North Dakota.

NSP-W has service territory in Wisconsin and Michigan, where it provides electric service at retail to customers. Through the FERC approved Interchange Agreement, costs related to generation and transmission facilities for the NSP System are shared between the two entities.

REQUEST FOR AN ADVANCE DETERMINATION OF PRUDENCE

NSP-M acknowledges the importance of involving the Commission in review of key energy investment decisions that will affect rates for our North Dakota customers. North Dakota statues provide that a utility proposing an energy facility may seek an ADP. Specifically, North Dakota law provides:

> **Section 49-05-16. Advance Determination of Prudence.** A public utility proposing to construct, lease, or make improvements to an energy conversion facility, renewable energy facility, transmission facility, or proposed energy purchase contract from another entity or person for the purpose of ensuring reliable electric service to its customers may file an application with the commission for advance determination of prudence regarding the proposal…

Under NDCC Section 49-05-16, the Commission may issue an order approving the prudence of an electric resource addition if three conditions are met:

a. The public utility files with its application a projection of costs to the date of the anticipated commercial operation of the electric resource addition;

b. The commission provides notice and holds a hearing, if appropriate, in accordance with Section 49-02-02; and

c. The commission determines that the resource addition is reasonable and prudent.

As demonstrated in this Application, the Bay Front Project is a reasonable and prudent investment for the purpose of providing electric service to our customers on the NSP-System.

If the Commission wishes to have a formal hearing on this filing, we are willing to prefile written testimony and exhibits in support of our Application. If this course is chosen, we will work with the Commission's Staff to determine a schedule to submit such testimony expeditiously. We are confident that the testimony and exhibits would further support the prudence of the Bay Front Project, provide additional support for choosing the Bay Front Project as a good resource for meeting customers' needs, and expand on the Project development process including cost projections.

Included with this application is our filing fee of $125,000 and an affidavit that supports the truthfulness of our statements.

DESCRIPTION OF THE BAY FRONT PROJECT

A. Background

The Bay Front Plant is located on approximately 50 acres of land on the shores of Lake Superior's Chequamegon Bay in Ashland, Wisconsin. The plant was originally constructed and began operation in 1916 as a coal-fired plant. In 1960, it consisted of

five boilers and six turbines. Two of the boilers and three of the turbines have since been retired. The three remaining boilers feed into a combined steam header system that can support three turbine-generator sets. The boilers burn a variety of fuels including coal, waste wood, railroad ties, tire-derived fuel, natural gas and petroleum coke to produce steam that drives the three turbine/generators to produce electricity.

The capacity equivalent of the existing boilers are 22 MW each for Boilers #1 and #2, and 28 MW for Boiler #5. Since 1979, the Bay Front Plant has converted more than four million tons of biomass, largely waste material (wood and sawdust) from local timber processing firms, into electricity. In 2007, Boilers #1 and #2 consumed approximately 200,000 tons of biomass, and in 2008 Boilers #1 and #2 consumed approximately 210,000 tons of biomass.

Boiler #5 uses cyclone combustion technology to generate the necessary steam levels to generate electricity. As a result, the type and quality of coal and its mixing ratio with petroleum coke is very important to ensure proper operation of Boiler #5. Locating an acceptable coal with the proper characteristics can be difficult and can result in increased delivery costs. In addition, because of the size and location of Boiler #5, the opportunity for price discounts on coal do not exist and extra handling of the coal is required, resulting in higher costs. Currently, coal prices for Boiler #5 exceed the cost of biomass for the plant on a per million Btu basis which is one of the primary reasons why this conversion to biomass makes sense.

In 1991 Boilers #1 and #2 were equipped with an upgraded air quality control system, which includes two gravel bed filters. The gravel bed filters are designed to remove more than 98% of the particulate matter. The system contains more than 300 tons of gravel bits, which are electrically charged to collect particulates from flue gas. In 1999, Boilers #1 and $2 were equipped with auxiliary natural gas burners to improve operating efficiency while firing on wood.

In 2008, we installed oxides of nitrogen ("NOx") emission control equipment on Bay Front Boilers #1 and #2. These investments will allow the continued use of biomass in Boilers #1 and #2 well into the future. However, we cannot economically continue to rely on coal and petroleum coke to power Boiler #5 due to long-term coal availability and cost issues, and significant costs relating to compliance with the recently reinstatement of the Clean Air Interstate Rule ("CAIR") and the pending federal mercury rules.

With the re-instatement of CAIR, Boiler #5 must further reduce its NOx and sulfur dioxide ("SO_2") emissions. Using banked SO_2 allowances will help minimize the cost of satisfying the SO_2 emission reduction targets in 2010. However, NOx emission

reduction targets will require additional investments in NOx control equipment or the purchase of NOx allowances. In addition, some of the NOx emission reductions or allowance purchases must be seasonally specific, resulting in higher costs. Utilizing biomass as a fuel will result in at least a 60 percent reduction in NOx emissions from Boiler #5.

Since Boiler #5's coal and petroleum coke fuel sources are more expensive than local biomass fuel and significant plant investments would be necessary in the near term to continue to operate the boiler on fossil fuels, we concluded it was prudent to pursue conversion of the facility.

B. Project Description

The major components of the Project include installing a biomass gasification system to convert waste wood to synthetic gas ("syngas") and modifying the existing Boiler #5 to burn the gas effectively to produce steam for electric power generation. Boiler #5 will also have the capability to burn natural gas. In addition, the biomass receiving, storage, and handling capabilities will be increased, and enhanced flue gas filtering equipment will be added to capture residual particulate emissions.

1. Gasifier

Biomass gasification has been studied and developed over the past half century and continues to grow in use. To date, biomass gasification installations in the U.S. have predominantly been small-scale (less than 5 MW) plants, however, some larger-scale plants have been installed in recent years.

The process of biomass gasification involves the heating of biomass in the presence of a limited proportion of air or oxygen to generate a gas made up primarily of carbon monoxide ("CO"), carbon dioxide ("CO_2"), methane ("CH_4"), longer chain hydrocarbons, and hydrogen ("H_2"). The syngas can then be fired in a traditional boiler. Syngas burns more efficiently and cleanly than solid fuel, including the biomass from which it was made.

Gasification takes place in a heated chamber. Fluidized bed media, cleaning and reinjection systems, fuel metering and air delivery systems will be an integral part of controlling the output of the gasifier. The gasifier project will also address char and ash handling needs and will include control system logic that can be integrated into the existing plant control system.

We focused on fluidized bed gasification technology due to the advantages it offers at this scale. Gasifying biomass in the fluidized bed configuration combines partial oxidation of hydrocarbons and de-volatilization of fuel. Biomass is introduced into a heated, fluidized bed furnace in the presence of less than 50% of the air necessary for combustion. At temperatures between 1,000°F and 1,600°F, most of the volatiles and water within the fuel are driven off as syngas, leaving ash and carbon. The energy content of the syngas is typically in the range of 100 to 200 BTU[4] per standard cubic foot (BTU/scf). While significantly lower in heating value than natural gas, oil or propane, this syngas compares favorably with pulverized coal in temperature and excess air requirements and contains much lower levels of sulfur and nitrogen.

The lower heat energy content of the syngas and the physical characteristics of the existing boiler will reduce the steam generating capacity of the boiler when burning 100 percent syngas. Ultimately, the reduced steam capacity will decrease the amount of electric generating capacity from the current rating of approximately 28 MW to an estimated 20 MW. However, the boiler will still retain the ability to generate 28 MW of electricity when burning 100 percent natural gas. As a result, the Project is not expected to impact the plant's total summer accredited capacity.

2. Modifications to balance of plant

To construct the Project, we will make several modifications to the Bay Front Plant. Specifically, we will retire or remove the equipment currently used to process the coal fuel for Boiler #5 including the coal crusher; the crusher reversing switch; the coal feeder system; and the dewatering bin which is used to cool the slag. In addition, certain air quality control equipment, multiclone separators and collectors will be removed. We will modify Boiler #5 so that it can burn the syngas and effectively produce steam for electric power generation, and add enhanced flue gas filtering equipment to capture residual particulates. Because the gasifier will be installed in the area currently occupied by the plant's weld and maintenance shops, those two building will be removed and replaced. We will also increase the Bay Front Plant's biomass receiving, storage and handling capabilities to accommodate the additional biomass that will be used at the plant upon completion of the Bay Front Project.

[4] British Thermal Unit

3. Implementation Schedule

Table 1 below provides a high-level implementation schedule for the Project. After receiving all necessary approvals for this project, engineering and procurement will occur in 2010. Primary construction is planned to begin no later than mid-2011, with commercial operation planned for October 2012.

Table 1
Summary of Project Milestones

Description	Estimated Completion Date
Award Study Contract	April 23, 2009
Begin RFPs for Major Components	October 13, 2009
Receive Air/Water Permit	February 11, 2010
All Contracts Awarded	June 25, 2010
Engineering Complete	July 6, 2011
Major Components delivered to Site	August 31, 2011
Start Construction	September 1, 2011
Foundation Complete	December 16, 2011
Construction Complete	August 15, 2012
Provisional Acceptance	September 21, 2012
Performance Testing Completed	October 12, 2012
Full Commercial Operation	December 1, 2012
Project Closeout	January 30, 2013

4. Projected Costs

NDCC Section 49-05-16 1.a requires a projection of costs to the date of the anticipated commercial operation of the electric resource. The Project is currently estimated to cost $58.1 million. Table 2 provides an estimate of project costs. Attachment A, a Trade Secret attachment, contains more details on the project costs.

Table 2
Bay Front Boiler #5 Gasifier Project
Summary Cost Estimate

Major Equipment/Systems	Cost
Mechanical System	**$29,053,250**
Electrical and Controls	**$ 2,010,500**
Civil/Structural	**$ 3,758,250**
Design & Engineering	**$ 3,140,000**
Contractor Overheads, other	**$ 4,474,700**
Sub Total Directs	**$42,436,700**
Indirects	**$ 6,657,650**
Escalation	**$ 3,740,623**
Contingency, 10%	**$ 5,283,497**
Project Total	**$58,118,470**

5. Energy Production

The Project is expected to generate approximately 124,000 MWh of electricity from Boiler #5 annually, approximately the same level of energy production as the current Boiler #5. The unit will be operated as a must-run resource to maximize energy production and minimize the overall cost of energy produced. Energy production at the Bay Front Plant overall currently averages around 325,000 MWh annually and is currently forecast to produce just under 300,000 MWh annually after conversion of Boiler #5. The lower forecast is dependent on a number of variables including energy market conditions, gasifier start-up period, and potential increases in maintenance time as the new and existing equipment ages.

C. Biomass Fuel Source

The Bay Front Plant currently utilizes approximately 200,000 to 210,000 tons of biomass annually. As a result, we have significant experience with the sourcing and handling of biomass fuel. The proposed gasifier is expected to consume as much as 200,000 to 250,000 additional green[5] tons of locally available biomass each year.

The existing biomass fueled boilers at the Bay Front Plant are supplied by a mixture of waste wood from wood products firms in the area and underutilized woody biomass that is typically left behind at existing forest harvest sites. This material includes treetops, logging slash, damaged trees, underutilized species and mortality classed trees.

After installation of the gasifier, the total fuel requirement of the plant will increase to approximately 400,000 to 460,000 tons of biomass. We anticipate that this fuel requirement will be satisfied with the use of waste wood from existing, new and expanding wood products firms, including harvesters, in northern Wisconsin, Michigan, and Minnesota and the underutilized woody biomass described above. Based on information from the United States Forest Service, less than 15% of this underutilized woody biomass available within 100 miles of the Bay Front Plant will be needed to help satisfy Bay Front's total fuel requirements.[6]

Our evaluation included a study of the availability of biomass fuel in great detail. Attachment B contains a copy of the testimony of James K. Witt and the associated studies of the availability of biomass submitted in the advance prudence proceeding before the Wisconsin Public Service Commission. Based on the results of these studies and our own efforts to assess the availability of fuel for the Project, it is

[5] The term "green" in this context refers to biomass with a moisture content of approximately 45 percent. Because of the higher moisture content, a green ton of biomass produces a lower temperature when burned than a dry ton. However, much of the biomass from forest residue is green.

[6] NSP-W is also working with the Wisconsin Office of Energy Independence, Wisconsin Department of Agriculture, Trade and Consumer Protection, University of Wisconsin - Madison and local agricultural experts to explore the feasibility of developing biomass plantations and grower cooperatives. The products of these initiatives would be chipped and used as fuel for the gasifier. Among other benefits, grower cooperatives could offer a centralized location(s) for the aggregation, processing and storage of the biomass, and provide just-in-time delivery to the Bay Front Plant.

reasonable to conclude that there are adequate sources of biomass at reasonable prices to provide fuel for the Project without compromising the supply of the raw material needed for paper manufacturing and other industries that currently use wood fiber in northern Wisconsin.

The price for woody biomass in 2012 is estimated between **[TRADE SECRET BEGINS TRADE SECRET ENDS]**. Because of uncertainty surrounding fuel cost forecasts, We also ran sensitivity analyses with prices at ±20 percent of the baseline price, and at ±40 percent of the baseline price.

Generally speaking, the lower end of the range corresponds to the continued use of wood and wood waste supplied by wood products firms in the area, while the higher end of the range corresponds to fuel from future energy plantations and grower cooperatives. Based on our efforts to develop multiple sources of biomass fuel, it is expected that the cost of biomass will fall within this price range. The baseline price for woody biomass delivered to Bay Front in 2012 was estimated at **[TRADE SECRET BEGINS TRADE SECRET ENDS]** and is based on the range of 2008 actual delivered cost of woody biomass to Bay Front, escalated to 2012 based at a compound annual rate of **[TRADE SECRET BEGINS TRADE SECRET ENDS]** escalation for each year after 2012.

In projecting future prices for woody biomass, we viewed the increases in biomass prices from 2005 to 2008 as anomalous, as those increases were primarily due to the increase in demand for biomass supplies resulting from a commitment to burn 100% biomass in Boilers # 1 and #2. Over the past two years, the demand for biomass for Boilers #1 and #2 has leveled off and is not expected to increase. As a result of demand stabilization, we expect annual price increases for biomass supplies to decline to the **[TRADE SECRET BEGINS TRADE SECRET ENDS]** (after 2012) levels identified above. In addition, our efforts to expand biomass markets in northern Wisconsin, including expanding supplies from existing sources, coordination with the WDNR on the development of biomass harvesting guidelines, and efforts to spur development of energy plantations have helped to stabilize prices.

The projected fuel costs as described above are shown in Figure 1 below.

Figure 1 [TRADE SECRET BEGINS

TRADE SECRET ENDS]

D. Cost to Customers

Table 3 provides the estimated annual revenue requirement associated with the Project that would be allocated to the North Dakota jurisdiction over the next five years. The calculation includes both capital and operating expenditure estimates. Table 3 also translates the revenue requirement impact into an estimate of the increased monthly cost to a typical residential customer using 750 kilowatt-hours.

Table 3
Revenue Requirements and Customer Impact of the Bay Front Project

	2010	2011	2012	2013	2014
Annual Revenue Requirement	$9,182	$89,660	$267,935	$533,587	$510,695
Typical Residential Monthly Bill Impact	$0.00	$0.03	$0.09	$0.18	$0.17

ASSESSMENT OF PRUDENCE AND REASONABLENESS

This Project provides a unique opportunity to use existing generating infrastructure, take advantage of gasification technology, and increase the use of the indigenous fuel source of northwestern Wisconsin to cost effectively meet customer needs. The increased use of biomass at Bay Front will help maintain fuel diversity in the production mix for the NSP System. There are very few other opportunities on the NSP System to add dispatchable resources at existing sites.

A. Cost Effective Biomass Resource

The Bay Front Plant is uniquely situated to use biomass. The plant is located in an area with considerable sources of biomass fuel stock that can be used to produce electricity. Furthermore, the staff at the Bay Front Plant has considerable experience working with the existing biomass forestry market to obtain fuel supplies for Boilers #1 and #2.

In addition, the small size of Boiler #5 lends itself to being utilized as a biomass generating resource. As noted previously, gasification technology has been utilized, for the most part, at scales smaller than would be required to repower Boiler #5. A repowering application much larger than Boiler #5 would present considerable technology risk, yet our technology investigations indicated that the application of gasification at the scale needed to repower Boiler #5 is feasible. Moreover, the total cost of power production will be lower because existing infrastructure can be reused as part of the repowering effort. Recycling existing boiler, fuel handling, and other equipment results in more cost effective power from the gasifier technology than was available from other biomass options.

B. Compares favorably to alternatives

To further evaluate repowering Boiler #5, we investigated the relative merits of the Project compared to four other alternatives:

1. Market Purchase Option: Continue to burn coal in boiler #5 until 2015, then retire boiler #5 and replace it with market-based energy and capacity;

2. Wind Option: Continue to burn coal in boiler #5 until 2015, then retire boiler #5 and replace it with wind resources located in Minnesota or the Dakotas;

3. Circulating Fluidized Bed Option: Continue to burn coal in boiler #5 until 2015, then replace boiler #5 with a boiler using circulating fluidized bed ("CFB") technology; and

4. Natural Gas Conversion Option: Continue burning coal in boiler #5 until 2015 then switch to 100 percent natural gas for the remaining life of the boiler, and run the boiler as a natural gas peaking resource.

We rejected the possibility of continuing to operate the unit using coal based on two primary issues. First, current state and federal air regulations affecting NOx emissions will require significant capital investment and ongoing annual expenditures for NOx emission allowances to continue the operation of Boiler #5 using coal.

Secondly, and most importantly, it has become increasingly difficult to find a suitable coal for use in Boiler #5. This boiler has very tight fuel performance specifications and few coals remain available that can satisfy its performance requirements. For example, when the mine that was the source of the previous coal used in Boiler #5 was closed, we performed multiple test burns of various types of coal over an eighteen-month span to find a replacement fuel. Due to these tight performance requirements, the limited availability of adequate coal supplies, and the transportation infrastructure needed to deliver the coal to Boiler #5, coal costs have exceeded -- and are projected to continue to exceed -- biomass fuel costs when measured on a dollar/mmBtu basis.

Based on these issues and considering the availability of relatively lower cost replacement capacity in the Midwest Independent System Operator ("MISO") footprint, the Market Purchase Option was a significantly lower cost scenario compared to the continued operation on coal scenario. Thus, we chose to utilize the lower cost alternative of market purchases as the baseline scenario.

Attachment C to this filing provides more information on the analysis of these alternatives including an examination of total system expansion and operating costs over an extended planning period using the Strategist model. The results of the analysis are expressed as the present value of revenue requirements ("PVRR") associated with each alternative. In each case the Strategist model found a slightly lower PVRR for the options examined. However, in each case, we believe there are other offsetting factors that favor biomass conversion. Following is a summary of the analysis for each option.

1. Market Purchase Option

As an alternative to repowering Boiler #5, we considered retiring the facility and replace its output from the wholesale market. As shown in Attachment C, the Strategist model predicts a slightly higher PVRR for the Project compared to market purchases over the planning period. In fact, the Market Option would appear to be the lowest cost option based on current planning assumptions. However, it is not reasonable to increase reliance on the market to meet long term resource needs. Planning models cannot adequately capture market volatility that could cause this option to be more costly with unforeseen variations from modeling assumptions. Relying on market capacity and energy to meet resource needs results in a largely uncapped cost risk that could soar during extreme weather conditions and/or serious disruptions in fuel supply or generating capability. For long-term energy needs, such as that currently supplied by the Bay Front Plant, it is more reasonable to rely on long-term resources that hedge against market volatility and consist largely of fixed and/or known costs.

Although the Project is projected to cost slightly more over the long run than the Market Option, it also provides benefits that the Market Option does not, such as:

- maintaining operation of an existing baseload resource;
- providing energy that can be used to meet renewable energy objectives;
- increasing portfolio diversity; and
- hedging against potential future, more stringent regulation of air emissions.

In addition, the Project avoids market risk and allows for the utilization of an existing site and infrastructure, including transmission, which is not considered in the cost of the Market Option. In light of these benefits and avoided risk, we believe that the costs of pursuing the gasification project are reasonable when compared to relying on the market.

2. Wind Option

A Wind Option was also considered as an alternative. The Wind Option assumes 33 MW of wind generation would be installed with an overall capacity factor in the range of 36%-40%. Under current generation accreditation rules, this option would be accredited at about 12% of nameplate capacity, or approximately 4 MW, for purposes of the MISO planning reserve margins. Because of the higher capacity rating of Boiler #5, additional capacity would need to be purchased from the market.

Considering the costs of ancillary services needed to integrate wind, the Gasifier Option costs virtually the same as this Wind Option, with $0.08/MWh separating the two options. The Project offers additional benefits compared to the Wind Option because it is dispatchable, maintains a baseload resource, and provides fuel diversity in both our overall and renewable portfolios.

3. Circulating Fluidized Bed option

Replacing the existing cyclone boiler with a 30 MW CFB was also analyzed. A new CFB boiler option has the highest capital cost of the alternatives studied because it amounts to replacing the existing boiler with nearly all new equipment. This option was rejected due to its very high costs and lack of benefits relative to the Project. In addition, this option requires significantly more construction over a longer period of time (removing the unit from service for an extended period). Attachment C shows that it also has the highest PVRR of all the options considered. For these reasons, the proposed Gasifier option was selected over the CFB option. Clearly, repowering Boiler #5 in a way that takes advantage of as much of the existing plant infrastructure as possible represents the most cost effective approach to expanding the use of biomass fuel resources.

4. Natural Gas Option

Instead of conversion to biomass, Boiler #5 could be converted to burn only natural gas, which was considered as part of our analysis. The Natural Gas Option would maintain the accredited capacity of Boiler #5, but the energy produced could be more expensive on a MWh basis. Natural gas costs would typically cause Boiler #5 to be dispatched only to provide peak energy during periods of high system demand. Boiler #5 would remain a steam-generator and would take longer to ramp up to full output capability compared to generation from a gas-fired combustion turbine. Boiler #5 operated on natural gas alone would be a relatively inefficient peaking resource and would probably be dispatched even less than assumed in our modeling. Thus, the actual cost of a unit of energy would be higher. In addition, the current baseload capability of Boiler #5 would be lost, and Xcel Energy customers would be exposed to potentially volatile natural gas fuel supply costs. While Xcel Energy has added natural gas generation to the NSP System, and will likely need to add more in the coming years, the Gasifier option for Boiler #5 provides better value for our customers than replacing this baseload unit with a 30 MW natural gas peaking unit.

C. Economic and Environmental Benefits

The conversion of Boiler #5 will help Xcel Energy meet renewable energy requirements in several of the states where we operate at reasonable cost. It also will reuse the existing site and infrastructure and result in a hedge against future environmental regulations.

1. Existing infrastructure benefits

The Project has the distinct advantage of providing for a dispatchable, high capacity factor, renewable resource without the need for new greenfield development and the associated financial, environmental or societal impacts of such development. The Project will use existing infrastructure and land resources, including:

1) the existing boiler and turbine/generator sets;
2) the existing plant site;
3) the existing transmission and substation; and
4) as a base for expansion within the plant footprint, the existing fuel procurement system.

2. Air Emissions

The Project brings environmental benefits because it is displacing a resource powered by coal and petroleum coke. The table below demonstrates air emission benefits associated with the conversion.

Table 4

Emission	Current Permitted or Actual Emission Rate	Post-project Emission Rate	% Reduction
NOx	0.80 lb/mmbtu	< 0.30 lb/mmbtu	> 60%
PM	0.60 lb/mmbtu	< 0.10 lb/mmbtu	> 80%
SO_2	3.20 lb/mmbtu	< 1.20 lb/mmbtu	> 80%
Mercury	0.000003572 lbs/mbtu	< .0000008 lb/mmbtu	> 80%
CO_2	213 lb/mmbtu (coal)	NET 0	100%
Opacity	40%	< 20%	>50%

3. *Hedge against future environmental regulation*

The North Dakota externalities statute prohibits the use of externality values in planning resource deployment or ratemaking.[7] The Commission has interpreted this statute to mean that it cannot consider environmental externality costs quantitatively, but that it can consider them qualitatively.[8] When making this qualitative assessment, the Commission has considered, for example, the potential for future environmental regulation to affect fuel costs in the future, including natural gas costs.[9] Applying that assessment to this proceeding, the Bay Front project provides additional benefits to customers beyond what has been presented in our analysis.

COMMUNICATIONS AND SERVICE LIST

We respectfully request that the following persons be placed on the Commission's official service list for all official communications in this case:

James A. Alders
Director, Regulatory Administration
Xcel Energy
414 Nicollet Mall, 7th Floor
Minneapolis, MN 55401

Megan J. Hertzler
Assistant General Counsel
Xcel Energy Services Inc.
414 Nicollet Mall, 5th Floor
Minneapolis, MN 55401

David H. Sederquist
Sr. Consultant, Regulation & Finance
Xcel Energy
2302 Great Northern Drive
Fargo, ND 58102

SaGonna Thompson
Records Specialist
Xcel Energy
414 Nicollet Mall, 7th Floor
Minneapolis, MN 55401

[7] N.D.C.C. § 49-02-23.

[8] *See Otter Tail Corporation Advance Determination of Prudence Application,* Findings of Fact, Conclusions of Law, and Order, Case No. PU-06-481 at ¶¶ 36-9 (N.D. P.S.C. August 27, 2008) ("Big Stone ADP Order").

[9] *Id.*

CONCLUSION

The Bay Front Project provides a unique opportunity to utilize an existing generating site and infrastructure, take advantage of gasification technology, and increase the use of the indigenous fuel source of northwestern Wisconsin to cost effectively meet the needs of our electric customers. Comparative analyses confirm the Project's costs are reasonable and will have a minimal impact on customers' bills. In addition, the Project is a dispatchable, high capacity factor, and renewable resource that will displace the use of coal and natural gas, thereby reducing emissions and the risk of market volatility.

Based on the information contained in this Application, Xcel Energy respectfully requests that the Commission order an Advanced Determination of Prudence regarding the Bay Front Project pursuant to NDCC Section 49-05-16.

Dated: September 23, 2009

Northern States Power Company,
a Minnesota Corporation

RESPECTFULLY SUBMITTED,

/s/

_____

JAMES R. ALDERS
DIRECTOR, REGULATORY ADMINISTRATION

ATTACHMENT A
Public Document
Trade Secret Data Has Been Removed

ATTACHMENT A
Bay Front Boiler #5 Gasifier Project
Summary Cost Estimate

Major Equipment/Systems	Cost

This document is Trade Secret

Attachment B1

(11 pages)

Direct Testimony of James K. Witt

Request for Approval to Construct a Biomass Gasifier at the
Bay Front Generating Facility

Before the Wisconsin Public Service Commission

OFFICIAL FILING
BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

Northern States Power Company – Wisconsin, an Xcel Energy Company, Request for Approval to Construct a Biomass Gasifier at its Bay Front Generating Facility

Docket No. 4220-CE-169

DIRECT TESTIMONY OF JAMES K. WITT

Q. State your name and business address.

A. My name is James K. Witt. My business address is 550 15th Street, Denver, CO 80202.

Q. By whom are you employed and in what capacity?

A. I am a Principal Fuel Portfolio Coordinator for Xcel Energy Services Inc. ("XES"), the service company for Xcel Energy Inc. ("Xcel Energy"). XES provides corporate services, including fuel procurement services, to Xcel Energy and its subsidiaries. I am appearing in this proceeding on behalf of Northern States Power Company, a Wisconsin corporation ("NSPW" or the "Company") and wholly owned subsidiary of Xcel Energy.

Q. What is your educational and professional background?

A. I have a Bachelor of Science degree in Natural Resource Management from the University of Wisconsin – Stevens Point. Throughout my career, I have held positions as an Environmental Scientist in several private sector and government positions. I began my career with Public Service Company of Colorado (now part of Xcel Energy) in April 1998 as an Environmental Analyst and accepted a position as Principal Fuel Portfolio Coordinator in October 2007.

Q. Would you state briefly the duties of your present position?

A. My responsibilities as Fuel Portfolio Coordinator include quantifying the fuel requirements of Xcel Energy's solid fuel-fired power plants, ensuring adequate supply and delivery of fuel, procurement of wood fuel, as well as tracking costs associated with the purchase and transport of solid fuel.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to support the Company's Application for a Certificate of Authority (the "Application"), Exhibit 1 (DDD-1) to construct, install and place in operation equipment that will produce synthetic gas from biomass for the production of electricity at the Company's Bay Front generating facility in Ashland, Wisconsin (the "Project"). In particular, I discuss the Company's conclusion that the Company will be able to obtain a sufficient, consistent supply of biomass for the Project.

Q. For which portions of the Application are you primarily responsible?

A. I am primarily responsible for those portions of the Application regarding biomass fuel availability and pricing.

Q. Are you sponsoring any exhibits in this testimony?

A. Yes, I will be referring in my testimony to two exhibits. Exhibit No. 3 (JKW-1) is the Assessment of Biomass Resources for Energy Generation at Xcel Energy's Bay Front Generating Station in Ashland, Wisconsin (the "ECW Study"). The ECW Study was completed by the Energy Center of Wisconsin in 2007. The purpose of the ECW Study was to identify potential sources of wood waste within a serviceable radius of the Bay Front Generating Facility (the "Plant"). A radius of 50 miles was chosen as a general guideline, which included the counties of Ashland, Bayfield, Douglas, Iron, Sawyer and

Gogebic (Michigan) (the "Study Region"). This study gathered information on mill and forest harvest residues generated in these counties. I am also sponsoring Exhibit No. 4 (JKW-2), which is a recent update of certain information in the ECW Study (the "ECW Study Update").

Q. What is the Energy Center of Wisconsin?

A. The Energy Center of Wisconsin ("ECW") is an independent, nonprofit entity whose stated purpose is to provide objective research, information, and education on energy issues to businesses, professionals, policymakers, and the public. The ECW provides these services through a staff, which includes analysts, architects, economists, engineers, evaluators, planners and communications professionals.

Q. Please describe the Plant's historical use of woody biomass.

A. As stated in the Application, the Company has been using biomass to produce electricity at the Plant since 1979. Since then, the Company has converted more than four million tons of biomass at the Plant, largely waste material from local timber processing firms, into electricity. Currently, boilers #1 and #2 at the Plant burn primarily biomass fuels. Boilers #1 and #2 consumed approximately 200,000 tons of biomass in 2007 and approximately 210,000 tons in 2008.

Q. How much additional biomass fuel do you estimate will be needed at Bay Front to provide fuel for the Project?

A. The Project will require an additional 200,000 to 250,000 tons of biomass annually.

Q. What are the current sources of biomass fuel for the Plant?

A. Since 1979, the Plant has used woody biomass discarded or under-utilized by the existing forest products firms from northern Wisconsin, Upper Peninsula of Michigan and

northeastern Minnesota. Over the past few years, the Plant has begun to use residue from existing forest harvest sites in that same general area. This forest harvest residue is often referred to as "slash material." In addition, we have used chipped or shredded creosote-treated railroad ties when supplies have been available.

Q. Please describe the sources of biomass that will be used for the Plant into the future, including for the Project.

A. Consistent with the information presented in the ECW Study and with the Company's experience over three decades of procuring significant quantities of woody biomass for the Plant, the Company plans to rely primarily on four sources of biomass material. These sources include: 1) the discarded wood (formerly referred to as "waste wood") from existing, expanding or new forest products firms; 2) forest harvest residue; 3) the mortality class of trees; and 4) creosote-treated railroad ties. In addition to these four sources, the Company could rely on biomass provided by "Other Removals" as that term is explained in the ECW Study Update. The Company is also working toward the development of two additional potential sources of biomass. First, the Company has been working collaboratively with private industry, academia and state and local government institutions on the concept of developing whole tree energy plantations to supply fuel for the Plant. Second, significant biomass may be available from governmental sources including street, parks, and right-of-way maintenance activities.

Q. Will the four primary sources you have described provide enough biomass fuel for the Plant, including the increased supply needed to fuel the Project?

A. Yes. The ECW Study (as updated by Exh. 4 (JKW-2)) estimates there are 931,567 tons of harvest residue generated annually within the Study Region. Within a 100-mile radius

of the Plant, the U.S. Forest Service ("USFS") – upon whose data the ECW Study relies – has estimated that there are 1.69 million tons of harvest residues generated annually. As most of the current biomass used at the Plant comes from within a 70-mile radius, the amount of residue generated within the "woodshed" that is available for the Plant is well in excess of one million tons annually. Second, while not addressed specifically in the ECW Study, the USFS estimates that 1.11 million tons of "mortality" biomass (in the form of dead trees not currently used for commercial purposes) is generated annually within a 50-mile radius of the Plant, and will also be used as a source of fuel. We estimate that between 1 and 2 percent of this mortality class of biomass (or 10,000 – 20,000 tons) would be available annually. In addition to these sources, the Company would continue to rely on existing supplies of biomass from mill residue (approximately 100,000 tons annually) and crushed or shredded creosote-treated railroad ties (10,000 to 30,000 tons annually).

Q. Are there other sources of biomass which could be used?

A. Yes. While we are confident these four sources will be more than adequate to provide fuel for the Project, there are two other categories of woody biomass which could be used. First, as indicated in the ECW Study Update, there is an additional category of woody biomass – not addressed in the original ECW Study – referred to as "other removals." This category of biomass includes unutilized wood volume of trees cut or otherwise killed by cultural operations such as pre-commercial thinning or clearing of forest land for non-forest uses. Based on available data, the ECW estimates that approximately 353,254 tons of this material is generated annually within the Study Region. Second, significant quantities of biomass may be available from efforts in

forests within the Study Region to reduce biomass that could trigger or exacerbate forest fires. The ECW is currently examining relevant data for this "fuel reduction" category of biomass.

Q. To what extent are the harvest residues and mortality sources commercially available to the Company at this time?

A. While the ECW Study discusses certain challenges to making all of the estimated tonnage of harvest residues commercially available, the Company has been assured by those who would supply these products that they will be able to meet the increase in biomass demand attributable to the Project from harvest residues alone, and that they will be able to do so in an environmentally sustainable fashion, including in compliance with the biomass harvesting guidelines recently developed by the Wisconsin Council on Forestry and to be implemented by the Wisconsin Department of Natural Resources (WDNR). With respect to the mortality resource, it is largely untapped from a commercial standpoint because there currently is no market for it. Another significant positive factor is that because the Project would not be operational until end of 2012, market participants will have incentives between the time the Project is permitted and completed to plan and develop not only the harvest residue resource but the mortality resource as well.

Q. Is there significant competition for the biomass sources that NSPW wishes to primarily rely on as fuel for the Plant?

A. No. Wood resources currently harvested in the Study Region and beyond are used primarily for paper and pulp manufacturing. However, the pulpwood used for those processes comes from the heartwood and sapwood of the tree, not the harvest residues

and other sources that the Company will rely upon as the primary sources of biomass for the Project.

Q. Has the Company considered how future circumstances might affect the availability of biomass for the Project?

A. Yes. For example, if Governor Doyle's Biofuels Initiative gains speed and scope, competition may develop for biomass from the state's existing forests under a sustainable forest management framework. One way the Company is already planning for such a contingency is to support the establishment of a system of biomass energy plantations. We have participated in efforts to develop energy plantation demonstration projects by working with representatives from the University of Wisconsin - Madison, the Wisconsin Office of Energy Independence, the Wisconsin Department of Agriculture, Trade and Consumer Protection, existing cooperatives, and local economic development organizations. According to an April 2009 presentation by Raymond Miller, the Forest Biomass Development Coordinator for the Michigan Agricultural Experiment Station at Michigan State University, biomass plantations may produce as much as eight times as much biomass per acre as conventional timberland, and more than double that of pulpwood plantations. While we believe that energy plantations may be necessary in the future to satisfy more robust demand for biomass in northern Wisconsin, we are confident based on the information we have gathered in support of the Application that more than sufficient biomass is available to satisfy demand that will be generated by the Project.

Q. Are there other ways to increase biomass supplies or otherwise respond to a scenario of constrained biomass supply?

A. Yes. So long as it could be done in a sustainable and responsible fashion, the level of harvesting in the existing forests could be increased up to a level of the annual allowable cut established by the appropriate management bodies, i.e., the WDNR, USFS, counties, or other forest landowners. Increasing the level of harvesting would have multiple beneficial impacts. Additional harvesting residues would be made available to the market. Additional mortality class biomass would be accessible and made available to the market, as well. Increased harvesting would produce more material that could be sent to the existing forest products industries in the region in the form of posts, poles, pulp logs, saw logs, and veneer logs. This increased supply should help to stabilize or decrease resource costs for the other wood products industries in the region.

Q. How has the Company helped to ensure that the biomass used at the Plant will be collected in an ecologically sustainable fashion and with minimal impact on existing resource procurement costs of other wood product industries?

A. Consistent with its environmental philosophy generally, the Company believes that any biomass harvesting system has to be designed and implemented in a sustainable fashion. It is for this reason that the Company has been involved in the Wisconsin Council on Forestry's efforts to develop the biomass harvesting guidelines and the WDNR's efforts to develop and implementation plan for these guidelines. If done properly, biomass harvested pursuant to the guidelines should actually increase harvest quantities in the long term. We support the harvesting guidelines and will encourage our suppliers to observe and utilize them on all of their harvest sites regardless of who owns the land. As incentive for suppliers to follow the harvesting guidelines, NSPW plans to give preference to those suppliers who agree to be contractually bound to observe them.

In addition, over the past two years, the Company has sponsored annual meetings with its current and potential biomass suppliers to discuss issues with the procurement and delivery of biomass to the existing plant. During these meetings, we have emphasized that the Company prefers to utilize only the harvest residues and not the entire tree to produce electric energy. We will continue to encourage the suppliers to segregate the harvested forest resource by sending the harvest residues to the Bay Front Plant and the higher quality forest resources to the appropriate best-use market. The Company's encouragement to its suppliers will be aided by the WDNR, USFS, and County adopting and implementing the biomass harvesting guidelines over the next few years. Similarly, the long-term, stable success of those biomass suppliers that provide appropriate raw materials to both the energy industry and the forest products industries will provide some self-governance in controlling what material is distributed among the several industries.

Q. Are there specific considerations that the Company will focus on with respect to the terms and conditions on which it purchases its biomass fuel supplies for the Plant?

A. Historically, the Company has paid for the biomass fuel used at Bay Front on a per ton basis, largely through contracts having a term of one year or less. The Company has used other fuel quality characteristics to help determine the biomass value, including moisture content, ash and dirt content, and chip size. In response to comments received from our current suppliers, others who are planning to participate in the biomass supply business, and consistent with the Company’s own business interests, the Company is considering the benefits of paying for biomass on a delivered BTU or energy content basis, or possibly on a delivered dry-ton basis. Future business arrangements will also utilize

multi-year agreements. We have already initiated efforts to test the use of the longer-term contracts; some now as long as 3 years. Changing the payment procedures is more difficult as it will require more frequent sampling and analysis of the biomass material for quality purposes. Visual inspections of the material delivered to Plant will continue. These inspections look for excessive moisture, ash and dirt. We will continue to evaluate improvements like these and others as we gain even more experience in using the biomass fuel.

Q. In its financial analysis in the Application, the Company uses a wide variance on the biomass fuel price. Please explain.

A. Because the biomass market is not as established as traditional fuels such as coal or gas, the Company determined that it should analyze the Project on the basis of a wide range of potential market scenarios. The lower end of the biomass price range used in the Application is based on the Company's pricing experience over the last 30 years, and shows that biomass is currently cost competitive with coal and natural gas. The upper end of the fuel price range reflects the unlikely scenario that NSPW will provide 100 percent of its biomass fuel from energy plantations if none of the existing biomass resources discussed in my testimony were available.

Q. Please summarize the Company's conclusions on the availability of biomass fuel for the Project.

A. Based on the ECW Study, the ECW Study Update, the USFS availability data and the Company's own efforts to assess biomass availability for the Project, the Company believes it is reasonable to conclude that there are adequate sources of biomass at reasonable prices to provide fuel for the Project without compromising the supply of the

raw material needed for paper manufacturing and other industries that currently use wood fiber in northern Wisconsin.

Q. Does this complete your direct testimony?

A. Yes.

Attachment B2

(33 pages)

Assessment of Biomass Resources for Energy Generation at
Xcel Energy's Bay Front Generating Station
in Ashland, Wisconsin

Exhibit 3 to Direct Testimony of James K. Witt
Request for Approval to Construct a Biomass Gasifier at the
Bay Front Generating Facility

Before the Wisconsin Public Service Commission

ENERGY CENTER OF WISCONSIN

Energy Center Report Number 240-1

Assessment of Biomass Resources for Energy Generation at Xcel Energy's Bay Front Generating Station in Ashland, Wisconsin

April 2007

Energy Center Report Number 240-1

Assessment of Biomass Resources for Energy Generation at Xcel Energy's Bay Front Generating Station in Ashland, Wisconsin

April 2007

Authors
Joseph M. Kramer & Sean Weitner, Energy Center of Wisconsin
Preston Schutt, CleanTech Partners, Inc.

455 Science Drive, Suite 200
Madison, WI 53711
608.238.4601
www.ecw.org

Project Manager: Joe Kramer, jkramer@ecw.org

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Paul Lundberg, Bayfield County Forest Administrator
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Table of Contents

Executive Summary

The purpose of this study is to identify potential sources of wood waste within a serviceable radius of Xcel Energy's Bay Front generating plant in Ashland, Wisconsin. A radius of 50 miles was chosen as a general guideline, which included the counties of Ashland, Bayfield, Douglas, Iron, Sawyer and Gogebic (Michigan). This study gathered information on mill and forest harvest residues generated in these counties. This information was supported through interviews with forest industry actors including government, NGO, academic researchers and business representatives. In order to switch to biomass as the sole fuel for generation at Bay Front, Xcel Energy estimates it would require approximately 360,000 tons per year of green chipped wood. The primary sources of wood residues were characterized as follows.

Harvest Residues. The wood left on site after timber harvest is termed harvest residue. This typically consists of tree tops and small diameter wood that are considered non-merchantable. Wisconsin Forest Management Guidelines[1] direct loggers on proper treatment of harvest sites in terms of biomass left for habitat. Forest administrators delineate through stumpage sales agreements the amount of biomass that can be removed based on soil replenishment needs. In most cases, these tree tops are not considered important for forest habitat or soil nutrition, and can be removed for other uses. In some cases, removal of harvest residues allows for quicker replanting and regrowth of the stand, and results in improved aesthetics.

The US Forest Service North Central Station estimates that about 860,000 tons of harvest residues are generated in the study region annually. Interviews with forest administrators and owner representatives provided additional insight into harvesting activities such as the intensity of harvest and fate of residues for their lands. Most indicated that additional removal of residues, especially tops, would be a welcome activity for their forests, particularly since this activity would not involve new road construction and could be accomplished during regular logging operations. Several logging contractors interviewed suggested that expanding their businesses to harvest and chip tops for sales to Bay Front is something they would pursue given sufficient guarantee of price and duration of contracts. This source alone appears sufficient to meet the fuel needs of Bay Front.

Mill Residues. Mill residues are generated through the primary processing of harvested timber. These residues are in three forms: fine (e.g., sawdust or wood flour), coarse (i.e., large enough to run through a chipper) and bark. The US Forest Service estimates annually generated mill residues in the study counties to be about 400,000 green tons. Because these residues are concentrated at mills, and can be a liability, mill owners have developed many options for beneficial use or merely disposal. Residues in this region are reported to be virtually all used for some other purpose (a large portion is currently delivered to Bay Front for fuel). Although regulators believe the use of residues is exaggerated, or at a minimum, some portion could be redirected for other uses if the price

[1] The Wisconsin Department of Natural Resources Division of Forestry provides specific directions in their Forest Management Guidelines. The guidelines can be downloaded from: http://dnr.wisconsin.gov/org/land/forestry/Publications/Guidelines/toc.htm.

is right, these residues are less likely to expand much beyond current agreements. Some reasons for this conclusion are:

1. Some of these residues are higher quality than harvest residues and may be in greater demand for competing uses such as animal bedding or wood pelleting
2. Unless the residues are currently being burned for disposal, they are now serving some competing purpose
3. A large proportion of these residues are not in a form that is optimal for Bay Front's operation, and may require additional processing before use
4. The quantities generated by any one entity, with the exception of Bay Front's current largest supplier, are relatively small and negotiations for these would entail many contract agreements with high transaction costs.

Dedicated Biomass. Contracting with local landowners to grow energy crops such as hybrid poplar may be a viable long-term strategy for wood fuel supply. Although there are negligible acres of Conservation Reserve Program lands, land rents are relatively low in this region. We estimate the poplars can be grown on these lands for somewhere between $15 and $30 per green ton, based on production estimates developed for Xcel's Minnesota Valley plant. Establishing plantations using non-native monocultures at production scale is a relatively new type of endeavor in Wisconsin, and environmental and regulatory waters have not yet been tested. While evidence suggests that a pilot plantation is justified, it would be prudent to wait for more information before moving into larger scale production. Experiences at Minnesota Valley plantations will provide valuable information on performance and implementation obstacles. Because of the nature of the Bay Front facility, non-woody biomass was not considered at length.

Introduction and Study Purpose

The combustion of wood to produce energy has a long history at industries that process wood and some electric utilities. Today, environmental, political and economic issues associated with fossil fuel use have driven home the importance of sustainability, and raised the profile of biomass as a viable sustainable fuel. Recent attention to the role of coal use in climate change has prompted utilities and other coal users to intensify their exploration of options for substituting biomass for coal. The key issue deterring substitution of biomass for coal in energy production is identifying a reliable, cost-effective and sustainable supply of biomass.

The purpose of this study is to identify potential sources of wood waste suitable for combustion at the Bay Front generating plant in Ashland, Wisconsin. Bay Front is a steam electric generating plant owned and operated by Northern States Power Company, a Wisconsin corporation and wholly-owned subsidiary of Xcel Energy, Inc. (d/b/a/ Xcel Energy).

Wood source examination is on a categorical level, intended to point Xcel Energy in the directions most likely to be fruitful in identifying sources of biomass fuel. In addition, the study includes examination of options to provide benefits to local environmental and sustainable forestry initiatives, while providing business opportunities for established or new wood harvest and processing businesses.

Xcel Energy currently plans to continue to burn wood and coal in the two spreader stoker boilers at Bay Front and is exploring options for converting all boilers to consume 100 percent biomass. This facility has used coal and wood for fuels since 1980, and has also burned railroad ties and shredded tires. Using wood for fuel instead of coal offers a number of emissions benefits, including reduced sulfur dioxide and nitrogen oxides emissions and short-cycle carbon dioxide.[2]

The use of wood for electricity generation can also benefit the timber industry in northern Wisconsin by providing another market for wood residues. Recent mill closings and production downsizings in Wisconsin, Minnesota and the Upper Peninsula of Michigan have hurt businesses and communities that rely on logging and timber processing. Increased demand for residues can help stimulate local businesses, with utility fuel purchases directly augmenting local and regional economies rather than leaving the state.

This report characterizes the types and quantities of wood wastes available within the six counties within a roughly 50-mile radius around the Bay Front plant. These counties include: Ashland, Bayfield, Douglas, Gogebic (Mich.), Iron, and Sawyer. This characterization relies on published and public data sources, and is bolstered by interviews with government and private actors. Figure 1 shows the study area.

[2] They have discovered that using either wood or coal fuel exclusively works best and avoids slag buildup on furnace walls (Wiltsee 2000). If not enough wood is available for eliminating coal use altogether, one option is to use coal during high energy demand periods (allowing the plant to operate at a higher output rating) and wood during lower demand periods.

Figure 1 - Study Area

Wood quantities and species are treated generally (i.e., as harvest residues and mill residues), since a variety of species are harvested and processed in the study region. Furthermore, moisture levels and quantities available are variable and not precisely inventoried. The data received from various sources required making some simplifying assumptions. Unless noted otherwise in the text, the assumptions are as follows:

1. Wood used at the plant is measured in "as-burned" form, with a moisture content between 35-45 percent, and an average heating value of 5,000 Btu/pound.
2. A cord of wood has a volume of 128 cubic feet and weighs about 5,500 pounds.[3]
3. Wood residues have an average weight of about 43 pounds per cubic foot.

Therefore, quantities and qualities of biomass discussed must be recognized as ballpark estimations. The variety of data sources and ages, variability in estimation methods, and wood characteristics all combined into a complex interplay that defies precision. The authors have made every effort to choose formulae and data we believe best approximate

[3] This is taken as a rough average from Taras 1956, in which measurements for large volumes of pulpwood were used to develop profiles for different tree species with bark on.

reality, and to include explanations of estimation methods used and sources of data so that alternative methods can be used if desired.

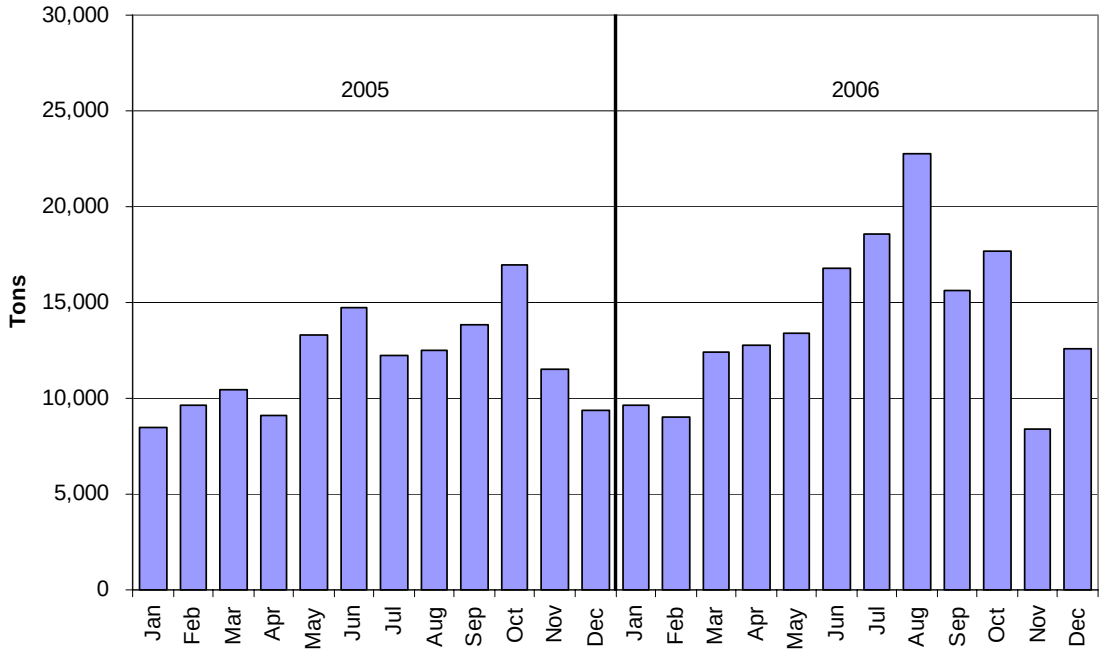
Demand Profile and Current Supply

Xcel Energy representatives have indicated that they could use as much as 360,000 tons[4] of woody biomass annually for energy production. This supply would allow the plant to operate both boilers year round exclusively on biomass. On-site storage is limited to about 7,000 tons, but could be expanded if coal storage space can be reduced.

The preferred physical form for the wood is chips that are roughly square and 2"x 2"x 0.5". Typical fuels received are chipped treetops, bark, railroad ties, sawdust and wood pieces from wood using industries. Wood received is further reduced by running it through an onsite hammermill before it is fed into the boilers. The facility can accept a limited amount of larger pieces or fines, but in order to not overwhelm equipment and cause processing disruptions, the large majority of wood must be in chip form. This limitation puts a premium on sources that can supply chipped wood.

Currently, Xcel Energy's biomass is being supplied by about 18 haulers ranging from a forest products company which has contracted to supply a minimum of 65,000 tons of wood wastes per year, to smaller companies that periodically deliver wood wastes. Figure 2 shows monthly delivered quantities of wood to Bay Front for 2005 and 2006.

Figure 2 – Bayfront Biomass Deliveries for 2005-6



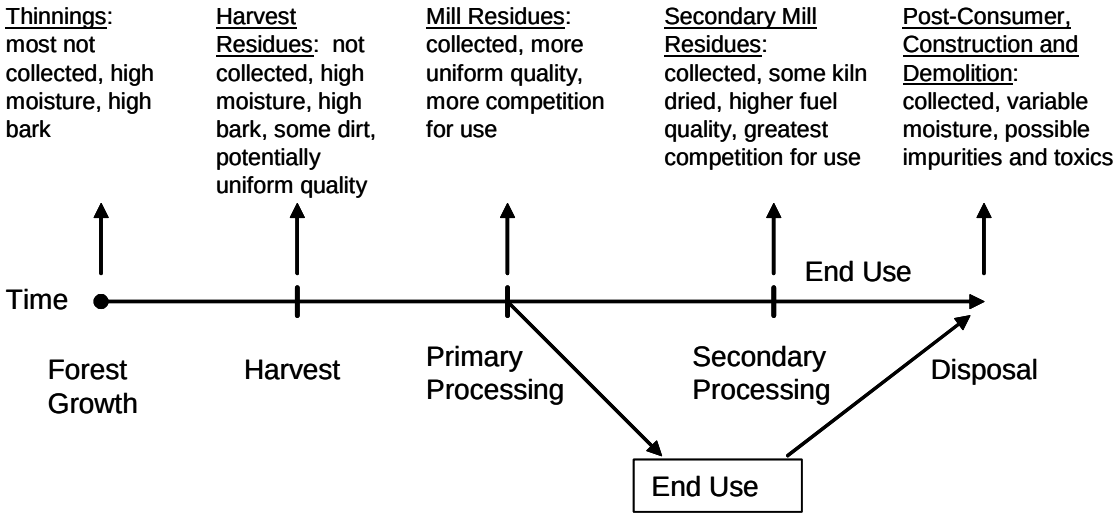
[4] The weight of biomass used at Bay Front generating station is in terms of "as-burned" tons, which may encompass residues with moisture content anywhere from about 35 to 45 percent (Donovan 2007). The residues received by Xcel Energy in 2006 measured between an average heating value per pound of 4,800 Btu for one source, to an average of 7,500 Btu for another (per Bay Front delivery records).

In 2006, the facility burned nearly 170,000 tons of biomass (with about 94,000 tons from the largest supplier), and 142,000 tons in 2005. To have a steady supply and operate at capacity exclusively with biomass, the monthly deliveries would need to be 30,000 green tons (i.e., top of the chart).

Potential Supply

The forest industry is the largest source for wood residues in the region. Figure 3 illustrates the typical pattern of wood use. Points in the growth, harvest and processing sequence are noted where residues are generated that have the potential for other uses.

Figure 3 – Wood Use and Residue Generation

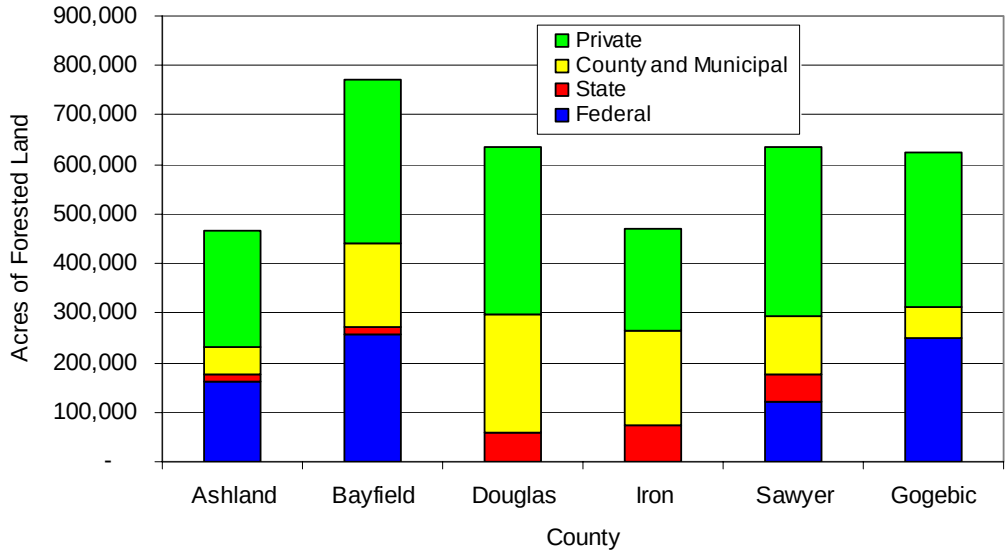


For this study we focused on harvest and primary processing (mill) residues because these activities are most likely to produce both low-value and high-quantity feedstocks. In addition, we examined the potential for establishing woody biomass plantations in the study area as a means of developing a long-term stable supply.

Forest Resources

The forest resources in the study area fall under four primary types of ownership. Figure 4 shows the ownership makeup of forested lands in each county as well as the overall forest acreage.

Figure 4 – Ownership Profiles for Forested Lands by County

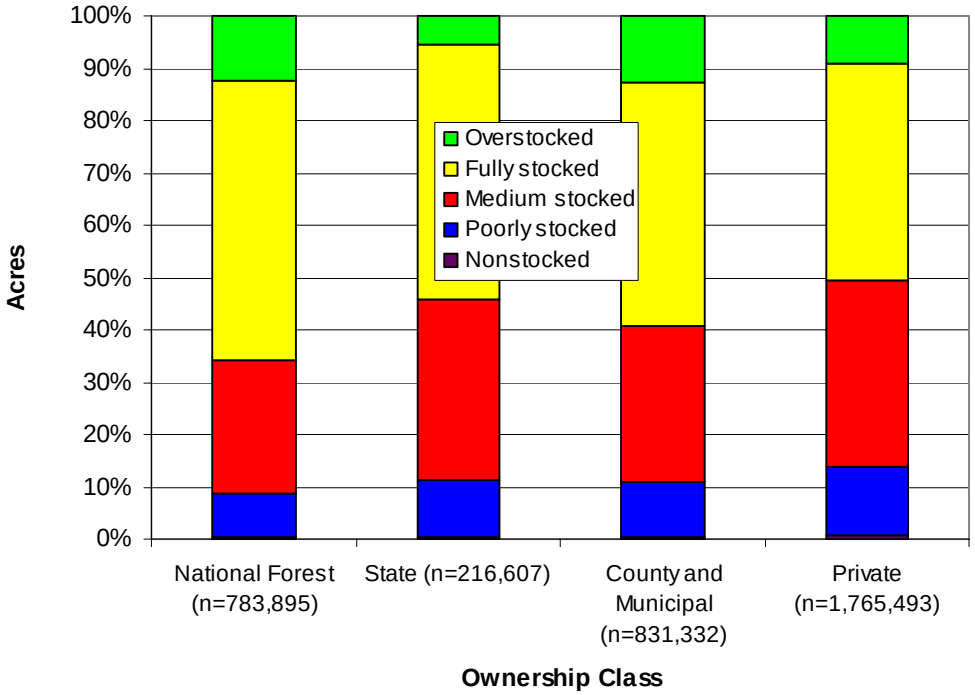


Source: US Forest Service Forest Inventory Mapmaker Version 2.1, 2005.

Bayfield County has the most forested acreage with nearly 773,000 acres. Douglas, Sawyer and Gogebic counties each have between 625,000 and 634,000 acres. Ashland and Iron Counties have about 466,000 and 471,000 acres of forested land respectively. For the combined counties in the study area, private parties own nearly half (1.76 million acres) of the forested land. County and municipal forests and federally owned forests (almost entirely in the form of national forests) make up 23 (830,000 acres) and 22 percent (790,000 acres) of the forested lands, respectively.

The density of biomass on the land can suggest opportunities for harvest that may benefit forest health. Issues specific to ownership class such as absentee ownership of private lands or stilted maintenance of federal lands due to litigation may lead to suboptimal densities. Figure 5 shows the measured stocking levels for forests by ownership class.

Figure 5 – Stocking Levels for Ownership Classes



Source: US Forest Service Forest Inventory Mapmaker Version 2.1, data for Ashland, Bayfield, Douglas, Gogebic, Iron and Sawyer Counties, 2005.

According to the US Forest Service, forested lands under each of these types of ownership are between six and 12 percent overstocked. All ownership categories have more than half of their forests at the "fully stocked" level or higher. The "National Forest" and "County and Municipal" owned lands had the highest percentage of acreage that was listed as overstocked.

Harvest Residues

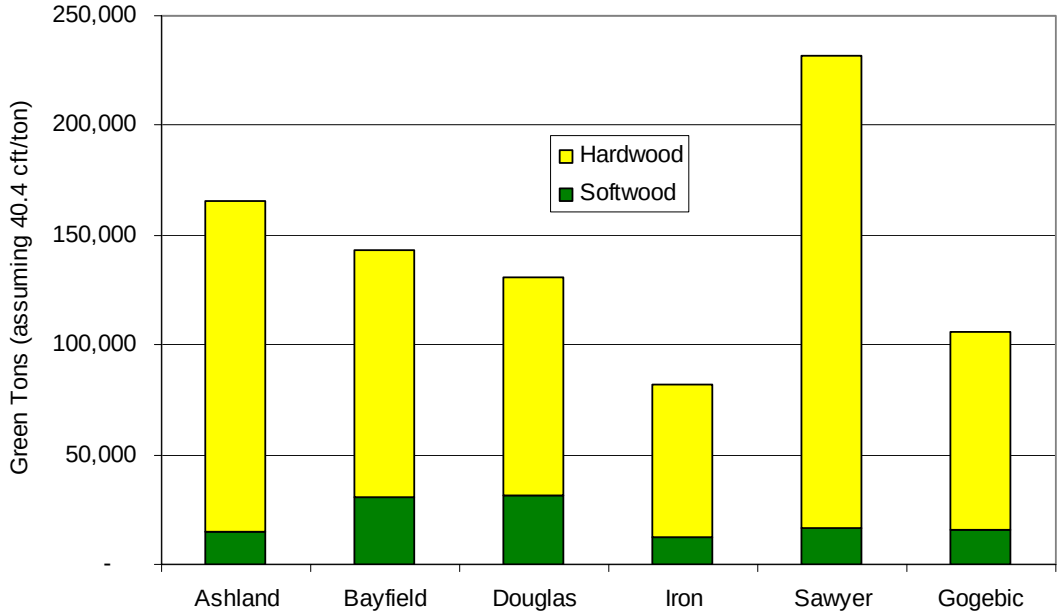
Harvest or logging residues are generated as a result of logging operations. Since these materials are defined as any unused tree parts that are left in the forest,[5] collection must be added to delivery as a key cost consideration. These residues are considered non-merchantable. Emergence of a market for them, such as fuel, would make them merchantable and loggers would need to pay stumpage fees to remove them from the harvest lands. Ideally, loggers would be financially motivated to remove residues as part of their operation (i.e., the sale price for the harvested residues would need to exceed stumpage fees, collection, and processing and transportation costs). This could help improve the profitability of these logging operations, allowing them to harvest more volume at each site before equipment relocation.

[5] The definition used by the US Forest Service for the data used in this report is: "the unused portion of trees cut or destroyed during logging operations including stumps, tops, limbs, cull sections of central stem, saplings, rough, rotten or dead trees."

The Forest Service North Central Research Station produces estimates of harvest residues based on amount of wood harvested. Estimates of harvest residues should be taken as general approximations, and will vary considerably with logging activity in the region.

Figure 6 shows the estimated annual amount of residues generated in each of the study area counties during the period of 2000-4.

Figure 6 – Estimated Harvest Residues Generated Annually by County



Source: North Central Research Station, United States Department of Agriculture, 2000-2004.

The six-county study area had an estimated harvest residue generation rate of about 860,000 tons, including 121,000 tons from softwoods and 739,000 tons from hardwoods. The fact that residues are generated, however, does not mean there are practical means of harvesting them. Removal of residues from harvested lands often requires addressing environmental, economic, regulatory and social issues. Finding a service provider that can, or already has, addressed these issues, and that has access to the biomass, is a significant benefit to the end user.

Sustainable Harvest of Residues in Wisconsin

Wisconsin loggers, in particular those who are members of the Great Lakes Timber Professionals Association, pledge to observe sustainable harvesting practices through adherence to the Wisconsin Sustainable Forestry Initiative annual training standard.[6] Those who obtain Master Logger certification have attained the highest level of training and expertise and have their practices reviewed by a board of industry experts "knowledgeable about the practice of sustainable forestry." Federal, state, county and local forest administrators, and in some cases nonprofit forest sustainability organizations, oversee harvest practices and contractually delineate what is to be removed

[6] See the Wisconsin Professional Loggers Association (now Great Lakes Timber Professionals Association) Web site at: http://www.wpla.org/wplacode.html.

for each site. In addition, the Department of Natural Resources Division of Forestry provides some more specific directions in their Wisconsin Forest Management Guidelines. For example, these include the recommendations that loggers create at least two to five bark-on downed logs greater than 12 inches in diameter per acre on harvested sites, and that they leave existing downed trees and standing dead trees undisturbed to the greatest extent possible.

Willyard and Tikalsky (2006) provide a literature review of ecosystem and biodiversity issues associated with collecting harvest residues. Studies suggest that the amount of biomass that must remain on a harvest site varies greatly based on the quality of the soils; poorer quality soils will require higher levels of biomass left on site to replenish them. The literature contains no formulas for predicting the percentage of generated residues that can be removed on any given site based on soil quality. Decaying fine woody debris defined as leaves, twigs and branches less than six inches in diameter, can help poorer soils maintain beneficial nutrient and carbon levels. Larger coarse woody debris such as fallen trees, standing dead trees (a.k.a. snags), and branches six inches or larger in diameter, provide important structures for smaller animal species and create microenvironments vital to forest ecosystems. Conversely, leaving all harvest residues on the land can impede replanting and natural regeneration of forest.

Another literature review conducted by Jan Hacker (2005) concluded that although little research has been done on habitats and tree species native to the Great Lakes states, research on a wide variety of forest types and soils suggests that effects of slash removal on nutrient budgets is short term. However, if the site does not have adequate reserves or will not obtain additional reserves, and is already nutrient poor, the impact will be more severe and long-term. Site-specific determinations of appropriate levels of residue removal must be made by qualified foresters with good knowledge of the land and the habitats. Conversations with foresters suggest they do base harvesting parameters on soil considerations (e.g., a forest with poorer soils may have stumpage quotes allowing harvest only down to 6 inches in diameter, whereas with rich soils, there may be no limitation on residue removal).

There are examples of assumptions in the literature, and standard requirements in some countries for residues left on site, but these appear to be done for convenience and do not reflect the site-specific nature of this relationship. From a practical standpoint, and perhaps providing a firmer number, the DOE/USDA's *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply* (2005) study states that current technologies only enable on average a maximum harvest of 65 percent of residues from sites (i.e., 35 percent of residues are not practically harvestable), without consideration of soil conditions.

Wisconsin logging operations, with the exception of some whole tree harvest operations, tend to leave treetops on site, largely due to the lack of a market for the lower quality wood (i.e., it is nonmerchantable). In time they will decay and could provide soil benefits. But structurally they are not nearly as important for habitat and diversity.

Therefore, should a market for this wood develop, loggers can add removal of treetops to their existing operations with little negative effect on harvest lands.

This combination of influences, while not amounting to a legal requirement for sustainable harvest, points to the feasibility of sustainable removal of treetops from logged lands in Wisconsin.

Current Harvest and Management Activities

An increase in Xcel Energy's demand for wood chips could mesh well with ongoing harvest and management activities in the region. The ability to "piggyback" harvest of treetops with traditional merchantable lumber harvests[7] would mean minimal environmental disturbance and better site conditioning for regrowth. Following are some summaries of current activities in regional forests.

National Forests. In recent years, much of the maintenance thinning and new harvest initiatives on national forest lands have been opposed by environmental groups. However, logging operations under existing contracts have continued. The US Forest Service would be interested in exploring options to have companies remove treetops from harvested trees which are currently left to decompose on the forest floors (Theisen, 2007). The Forest Service would be amenable to negotiating more favorable stumpage rates with companies who want to remove and use tops from harvested trees. Similarly, the Forest Service is currently paying contractors to go in and cut down undesirable species which are then left on the site. They would be interested in exploring agreements to have contractors cut and remove these for a fee, creating conditions more conducive to regrowth.

County Forests. Counties in the study area have varying degrees of logging activity on their county forest lands as described below.

- Ashland County has experienced a slowdown in harvesting on county land, which could pick up after the spring thaw. Contracts are set up on a per-cord basis and competitively bid, with harvest down to 4 inches. Much slash is left behind.
- Bayfield County estimates contractors are harvesting 30-50,000 cords per year and are growing 90-100,000 cords. They project that they could harvest 600 forested acres per year sustainably for the foreseeable future. Their contracts require that the loggers take all that is above 8 inches in diameter, and most of the treetops are left on site.
- Douglas County contracts for harvesting of about 5,000 acres per year, with harvesters processing down to 2-inch diameter treetops. The loggers do substantial chipping and are often permitted to take the tops (although not when on poorer soils requiring carbon and nutrient supplementation). Chips are sold to "Fuels for Schools" participants, mills, and businesses in Minnesota. The county is planning to market scrub oak chips for fuel.

[7] According to one logger, this would literally mean the tops could be hauled out on the skids on top of the lumber they are harvesting. No new roads would be made and loggers would have improved efficiency because they could remove more wood before having to relocate their equipment.

- Iron County has approximately five contracts out for harvest and tops are generally left on site.
- Sawyer County sees about 2,600 acres harvested per year, and contracts cutting down to 4 inches in diameter, although some go down to 2 or 3 inches. Some harvesters do whole tree chipping. Nonmerchantable tops are left on site.
- Gogebic County estimates they have about 750 (of their total of about 50,000) acres of mostly hardwoods currently under active harvest. They have very few loggers that do whole tree chipping, but most harvests are down to about 3-inch diameter, leaving smaller tops on site. They do not have restrictions on removal of biomass, so tops could be removed.

Forests on Tribal Lands. The Bad River reservation has 125,000 acres of forested lands owned by the tribe and individuals. This forest is managed under their integrated resource management plan and approximately 400 acres are harvested each year. The Bureau of Indian Affairs (BIA), the federal organization charged with managing assets on tribal lands, estimates that harvest residues of about 15 tons per acre, or a total of 6,000 tons, are left on the land each year. While both tribal and BIA representatives saw increased use of these residues as positives for the landowners, they pointed out that current BIA contracting practices limit these possibilities. Currently, harvesters are charged a cordwood rate for residues removed from harvested lands which does not reflect the lower value. Changing this practice will require that the Council of Elders request BIA reduce the amount charged to harvesters for residue extraction. Removal of tops from harvest lands can clear the way for tribal initiatives such as re-establishment of white cedar forests.

Local and Private Landowner Healthy Forest Initiatives. A number of localities in the study area have Healthy Forest Initiatives. In addition, a member-owned forestry-based cooperative, the Living Forest Cooperative, helps owners of forested lands develop sustainable forest management plans for their properties to generate income and improve the health of the forest. The cooperative is also encouraging landowners and farmers to take a more active role in managing their forests. As long as long-term soil quality issues are monitored, they see increased demand for traditionally nonmerchantable wood as a means of helping private landowners finance active forest management. A cooperative representative said he would like to see wood fuel pricing based on fuel value so that less marketable but high fuel content wood such as oak could be cost effectively harvested as well.

Commercial Loggers

Loggers interviewed for this project present the single most promising and direct option for increasing wood fuel use at Bay Front. These operations already do harvesting on federal, county, local and privately-owned forest lands. Negotiation for delivery of harvest residues with these loggers offers an apparent direct route through the more complex negotiations that would be required to work with the multitude of forest owners. Interviews suggest some loggers have interest in expanding their operations to include residue extraction, processing (chipping) and delivery to wood chip users (and some are already planning to do this). Current wood chip users include school districts, industrial

users and Xcel Energy. By all accounts, many harvesting operations leave an ample quantity of biomass on the land in the form of treetops that could be harvested if there was a financial incentive to do so. Some loggers have suggested that prices at or above break-even per delivered ton for wood chips, and contracts for a year or more, may be enough to get them (and others) involved, and that with slight expansions to their operations they could supply more than enough chipped wood to meet Bay Front's needs. Increased demand for chipped residues may also allow loggers to negotiate with landowners to return to recently logged sites to chip and remove treetops left on the land, thus improving both the aesthetics and regrowth conditions for these lands.

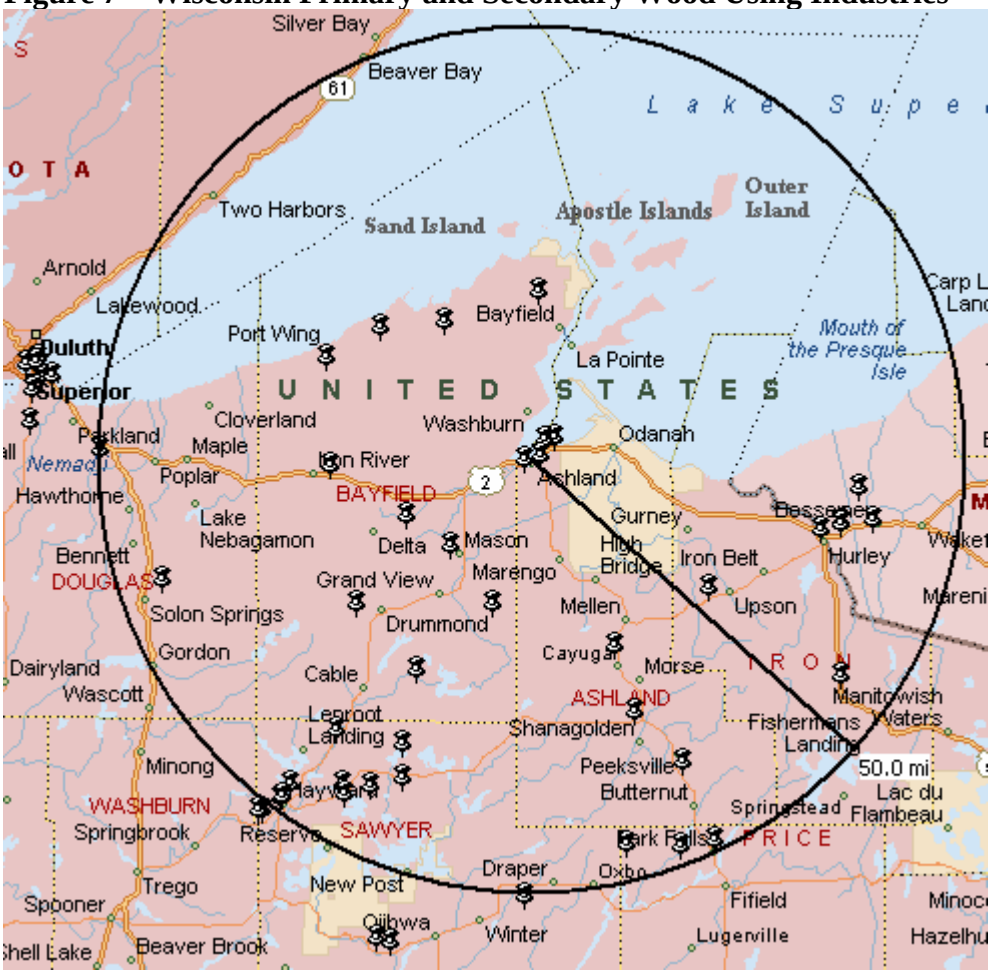
Mill Residues

In this section we characterize the current generation and fate of harvest and primary wood using industry residues in the counties within a 50-mile radius of the Bay Front plant. Primary wood-using mills take raw products from the forest such as logs and chips and produce lumber, utility poles, oriented strand board, veneer, and sawdust. Secondary wood-using industries use products from the primary wood-using mills and produce anything from flooring, furniture, and cabinets to log homes. The US Forest Service North Central Station has gathered information on residues from primary industries, but there are no centralized records of residues produced from the secondary wood-using businesses. Therefore, while they may offer a significant source of biomass for Xcel Energy, the secondary wood using industry residues are not examined in this study.

Production (of wood products, not residues) and organizational data on primary and secondary wood-using industries are available from the Wisconsin Primary and Secondary Forest Industries Databases created by the University of Wisconsin Department of Forest Ecology and Management.[8] Figure 7 shows a plot of the locations of Wisconsin primary and secondary wood processing industries in counties that fall within the study region.[9]

[8] The databases can be downloaded from the following site: http://www.woodindustry.forest.wisc.edu/.
[9] Plotted points in Gogebic County and Price County are included because these firms had a Wisconsin study area county listed as their county of operation but coordinates put them where they appear on the map. Some industries did not have coordinates in the database and so are not included on this map.

Figure 7 – Wisconsin Primary and Secondary Wood Using Industries



Map generated using Microsoft Map, and location data from the Wisconsin Primary and Secondary Forest Industries Databases, University of Wisconsin, 2006.

These northern Wisconsin and Michigan counties have historically had thriving forest product industries. The Wisconsin Primary and Secondary Wood Using Industries databases and Michigan Department of Natural Resources Forest Industry Database[10] list 46 operating primary and 33 secondary wood-using businesses in these counties. Table 1 lists the numbers of primary and secondary wood using industries in each study county.

[10] The database can be accessed at: http://www.dnr.state.mi.us/wood/quermain.asp.

Table 1 – Wood Using Industries in the Study Area

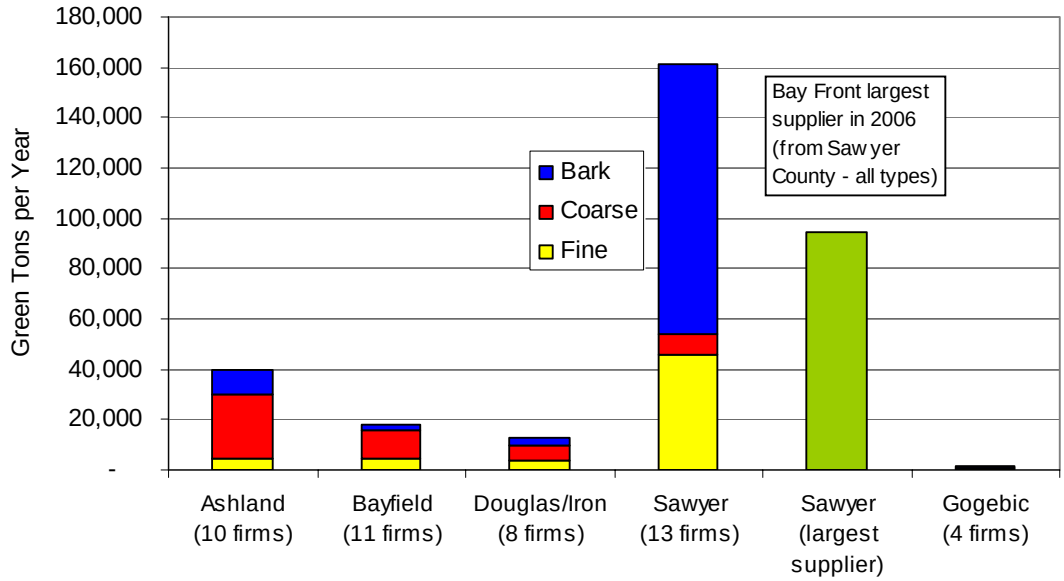
	Primary	Secondary
Ashland	10	6
Bayfield	11	3
Douglas	4	6
Iron	4	2
Sawyer	13	11
Gogebic	4	5
Total	46	33

Many of the records in these data sets do not have a reported volume of production. For those that do, the largest reported outputs are a veneer producer in Ashland County that processes between five and seven million board feet of wood per year, and three sawmills, two in Ashland county and one in Sawyer County, that each manufacture between three and five million board feet of lumber per year.

Primary Wood-Using Industry Wastes

Mill residues from primary wood-using industry production are categorized as fine, coarse and bark. Fines are too small to be suitable for chipping. Coarse residues are larger pieces that could be fed through a chipper. Bark is considered the lowest value wood residue from these operations and is most often removed before other processing occurs. Figure 8 shows the overall volume of reported residues produced in these counties from primary industries, broken down into residue types. In addition, the total quantity of residues from the largest current supplier to Bay Front is included (as a solid green bar).

Figure 8 - Reported Primary Wood Industry Mill Residues by Type



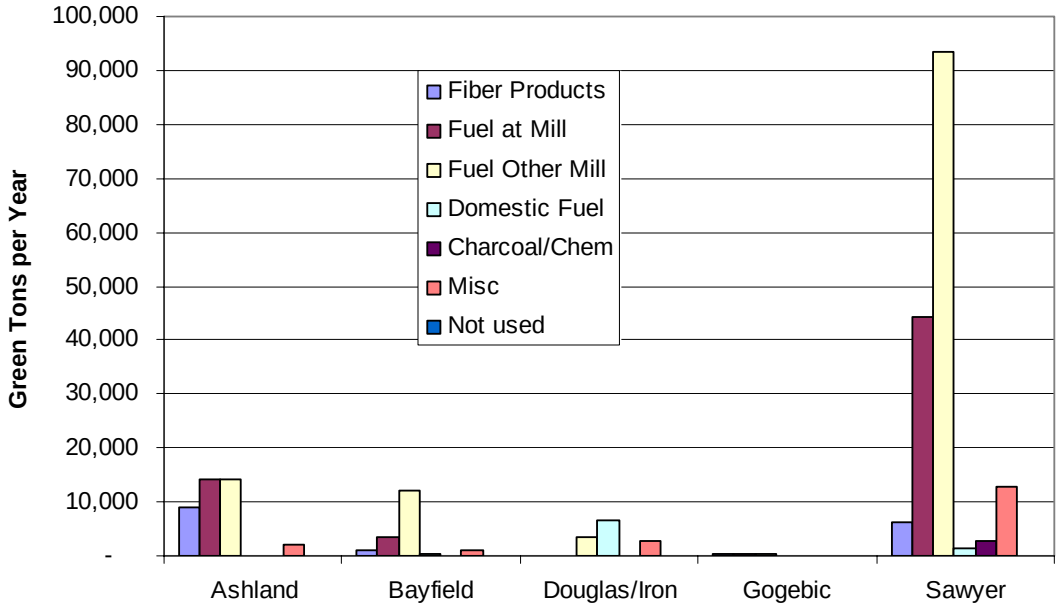
Source: North Central Research Station, United States Department of Agriculture unpublished data from 2000-2004, obtained 2007. Douglas and Iron counties are combined by USDA to reduce potential for identification of residue amounts with individual businesses. The Sawyer (largest supplier) bar is some combination of residue types and so is not subdivided into bark, coarse and fine.

Sawyer County has by far the largest amount of reported mill residue generation at about 161,000 tons per year. However, Xcel Energy has already tapped into the largest residue generator, which supplied 94,000 tons of biomass to Bay Front in 2006. This provides some perspective on the limited potential for expanding residue use from this sector.

Current Reported Uses of Mill Residues

A study by researchers at the U.S. Forest Products Laboratory on mill residues generated in the United States from primary timber processing operations found that about 98 percent was reportedly used for other products or energy (McKeever and Falk, 2004). This suggests that just about two percent are available for other uses. Recent data on Wisconsin primary wood-using industry mill residues shows even lower residue availability. Figure 9 shows residue volumes and recorded uses for counties in the study area.

Figure 9 – Mill Residues Generated and Reported Uses



County	Fiber Products	Fuel at Mill	Fuel Other Mill	Domestic Fuel	Charcoal/ Chemicals	Misc. Uses	Not used
Ashland	8,920	14,343	14,259	-	-	1,961	2
Bayfield	1,092	3,471	12,042	235	-	903	-
Douglas/Iron	-	-	3,535	6,523	-	2,676	-
Sawyer	6,265	44,369	93,567	1,555	2,787	12,918	-
Gogebic (MI)	505	375	322	5	-	3	-

Source: North Central Research Station, United States Department of Agriculture unpublished data from 2000-2004.

Of the estimated 232,000 green tons of mill residues generated by primary wood-using industries in the study region, only two tons were reported to be "not used."[11]

[11] Communications with forest industry experts suggest that reports of mill residue use may be exaggerated, meaning there are likely to be more residues available for alternative uses than these data sources indicate.

Xcel Energy currently has a number of agreements with wood industry businesses to buy residues for Bay Front (see discussion under Demand Profile and Current Supply). With the exception of the largest supplier, these agreements do not have minimum quantity requirements. They are relatively informal, offering a fixed rate for biomass delivered. Competing wood-using industries for some of these residues, such as wood pelleting operations, are expanding in the state and region, and will offer higher value market alternatives that will contribute to increased competition, reduced biomass supplies, and higher biomass prices for electric generating plants like Bay Front.

Securing a reliable fuel supply into the future is an important goal. In light of this, it appears that mill residues, unless amounts given by industry are substantially underreported, may not be a viable source much beyond existing agreements.

Dedicated biomass

The long-term availability of secondary biomass supplies such as wood waste from milling or clearing operations is subject to market conditions as well as potentially variable output from the suppliers. A more stable solution is to create a dedicated supply of primary biomass. This can be done on land that Xcel Energy owns or leases, or by entering into contracts with farmers who both own the land and will cultivate the crops. While this does not provide complete insulation from market pressures, dedicated energy plantations provide a predictable, uniform, secure supply of biomass.

In order to produce biomass at a sufficiently low cost to compete with other fuel sources, a biomass plantation must produce crops that require minimal cultivation. Two different kinds of biomass are typically considered for this purpose: short-rotation woody crops and grasses. We will consider how successfully energy crops can be grown in the study area, and outline potential production scenarios.

Short-rotation woody crops

Short-rotation woody crops (SRWC), including such species as cottonwood/poplar, willow, silver maple and red pine, can grow to merchantable size in 5 to 15 years, depending on the application, species and plantation. The most studied crop, as well as the one considered most suitable for this region, is the hybrid poplar. We will use poplars as our main example in this section.

SRWC can serve as a combustible fuel for power plants, although they were first investigated as a source of lumber and fiber for papermaking, and later as a source of cellulose for advanced biomass processing. Xcel Energy's Minnesota Valley power plant is investigating a conversion to Whole Tree Energy (WTE) using hybrid poplars, cottonwoods and willows (Ostlie 2003). WTE requires a plant retrofit and uses the trees as cut with minimal further processing; the Bay Front model of using wood chips is a significantly different operation.

To understand all of the factors that influence whether SRWC can be profitably grown in the study area, we will outline issues related to establishment, harvesting and handling, combustion and the environmental impacts of growing.

Establishment

Successful establishment of a SRWC plantation is dependent on many variables—most critically soil moisture, but also acidity, soil texture and nutrient availability.

Table 2. Recommended soil characteristics for hybrid poplar plantations

Soil characteristic	*Parameter*
Texture	Loams, not clays (Ostlie 2003)
Water-holding capacity	10 in. or greater in top 60 in. of soil (Hansen 1993)
Water table depth	1 to 6 ft. (Hansen 1993)
pH	5 to 7.5 (Hansen 1993)
Slope	Less than 12% (Riemenschneider 2007)

Hybrid crops are bred to emphasize particular qualities in order to find the most compatible species for a given environment. Researchers warn that current soil classifications are insufficient to consistently predict how a tree from a specific genetic line will perform in a given soil, and that common indicators such as crop equivalency rating (CER) have not correlated to successful planting (Ostry 2007). However, soybean performance has been noted as a reasonable indicator of poplar suitability (Riemenschneider 2007). Some trial-and-error may be required to arrive at the genetic line that will generate the most Btu/acre for a given plot.

The model of a successful SRWC plantation is a single species of tree in evenly spaced rows. Spacing for energy density is another variable that may require successive plantings to optimize for the plantation. A peculiar characteristic of hybrid poplars is that biomass per tree does not decline, but stays constant or may even increase, the closer the trees are spaced—albeit at a cost of tree longevity.[12] This makes them ideal as an energy crop—they can be grown densely so long as they are harvested frequently.

The feasibility study for the Minnesota Valley plant estimates that by growing poplars, cottonwoods or willows on 5.3 ft. centers, the plantation will yield 24.5 dry tons/acre, or 47 green tons/acre, after five years. This spacing is predicated on the use of high-productivity harvesters such as those proposed by Energy Performance Systems (EPS), which also developed the Whole Tree Energy plant model. L. David Ostlie, president of EPS and author of the Minnesota Valley study, says that he has determined through his most recent growing trials that 5.0 ft. spacing is ideal (Ostlie 2003, 2007).

Other sources which consider more traditional harvesting methods recommend 8 or 10 ft. centers (Hansen 1993). If we carry forward the other assumptions from Minnesota Valley study, the yield changes to 11 and 7 dry tons/acre, respectively.

[12] This phenomenon is popularly demonstrated through an experiment called the Nelder Wheel. For a look at poplars planted under such a strategy, see DeBell, Dean S. and Constance A. Harrington. 1997. "Production of *Populus* in Monoclonal and Polyclonal Blocks at Three Spacings." Canadian Journal of Forest Research. Available online at http://bioenergy.ornl.gov/reports/debell/chapter5.html (accessed March 2007)

With hybrid poplars, the initial planting is done with cuttings all from the same clone species, typically less than a foot long and roughly 0.5" in diameter. Weed control is required for the first three years, and may not be necessary once the tree canopy has developed (Ostlie 2003).Cultivating the plantation in its early years is critical to its future health and optimum yield.

Once a hybrid poplar plantation has been cut down, the trees will sprout again from their stumps. While weed control will again be necessary, the trees' root systems are already established and will grow for another harvest, possibly in less time than the first plantation. In practice, however, it is likely that during the maturation period for the first planting, a better genetic line will have been developed and that farmers will be better served by pulling up the old stumps and planting new cuttings (Stanosz 2007). The same is likely to be true for any monoculture SRWC for the foreseeable future. These future costs, i.e., stump removal and avoided establishment costs due to stump resprouting, are fuzzy and were not estimated.

Harvesting and handling

The intended harvesting method limits how densely you can seed a plantation. Energy Performance Systems is developing a rapid harvester for use on SRWC plantations that they expect to offer for sale in 2008. The harvester, which is estimated to operate for $101/acre, is designed to handle plantations with spacing as low as 40". As described in the Minnesota Valley study, "The harvester is a large, rubber-tracked machine designed to continuously travel down each row of trees at relatively high speed. Each tree is cut off, guided into an accumulation area and batch-dumped onto a trailer towed behind the harvester." After a 5-year growing season with 5.3 ft. centers, a typical hybrid poplar is roughly 6-8" in diameter and 30-35 ft tall (Ostlie 2003, 2007). For economic harvesting using any type of harvester, it is recommended that SRWC not be grown on sloping soils.

Short-rotation woody crops have been specifically selected as a potential feedstock for the Bay Front plant because it already consumes wood chips as a fuel and has wood handling systems in place. Bay Front does not chip its own wood, however, so the facility would need to be expanded or a third party would have to provide these services. As previously discussed, established loggers are interested in expanding their operations to include chipping and delivery.

Combustion

Chipping SRWC as harvested will create green wood chips. Bay Front currently uses a mix of wood chips as fuel, including green chips, which burn at a lower Btu than oven-dried wood because energy spent during combustion to drive the moisture from the wood does not contribute to power output. In a scenario where Bay Front uses all biomass fuel, the amount of fuel needed could be significantly reduced if excess heat exhausted by the plant were used to dry the chips. Green wood chips (assuming 50% moisture) burn at

5.74 MMBtu/ton; air-dried wood chips burn at 13.7 MMBtu/ton; and oven-dried wood chips burn at 17.2 MMBtu/ton.[13]

Environmental impacts

Compared to row crops, SRWC require very little cultivation and greatly reduced demand for chemicals such as fertilizer or pesticides. Also unlike row crops, SRWC can provide significant erosion control and are expected to grow exceptionally well in soils traditionally reserved for row crops.

Studies have concluded that monoculture SRWC plantations do not exhibit the species richness of forests or pasturelands, but are also not "biodiversity deserts" as suggested by some critics. These plantations show greater overall diversity than lands planted with row crops, and they also outperform shrublands and grasslands in some characteristics.[14] Willyard and Tikalsky (2006) provide a review of biodiversity studies related to monoculture plantations.

Beyond biodiversity, establishment of SRWC plantations will have to balance known environmental benefits (e.g. displacing coal in power plant operations with a short-cycle carbon fuel) with concerns about introduction of non-native species and possible effects on surrounding ecosystems. Some environmental questions may not have clear answers even after plantations have been established.[15]

As emphasis shifts in our region toward energy independence both from other nations and from other states, owners of marginal croplands that are currently in reserve will feel increasing pressure to bring that land back into production for energy crops. With their multi-year growing seasons, SRWC may prove to be an ideal middle ground between intensive cultivation for commodity products and nonproductive CRP-style management.

Grasses

Because the material handling systems in place at the Bay Front plant require biomass in the form of wood chips, we will not consider the use of grass energy crops at length. However, as research into energy crops progresses, it may be that grass crops will be a more successful choice for energy plantations than woody crops, and if this should be the

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[13] 2004. "Fuel Value Calculator." USDA Forest Products Laboratory Techline. July 2004. Available online at http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf (accessed March 2007)

[14] More specifically, a review of research has suggested that monoculture SRWC plantations have greater avian abundance and species richness than shrublands, and greater small mammal abundance and species richness than grasslands (Willyard and Tikalsky 2006).

[15] Some common questions emerge concerning use of native versus nonnative species and mixed forest versus monoculture. SRWC plantations tend to consist of clones of a hybrid bred for qualities that have been determined to complement the characteristics of the plantation. These hybrids are, by definition, not native species, and some object to the introduction of such species for fear of the effect they might have on ecosystems. Pathologists have been deeply involved in SWRC research because disease resistance is an obvious virtue for an energy crop. One concern, however, is that planting hybrid poplars too near to native cottonwoods will result in cottonwoods being hybridized with the nonnative species, and that an infestation or disease that is trivial to one species could be troublesome for the other (Ostry 2007).

case, the time horizon may be sufficient for handling equipment to be installed at Bay Front.

While switchgrass is the best-known potential energy crop, there are many native and non-native grasses that are of interest for their ability to produce fiber and fuel, including such exotic species as sorghum and miscanthus. The major issue with using grasses in power plant operations is the state of the harvesting technology, combined with greater handling difficulty at the plant and greater silica deposits during combustion (i.e. compared to woody biomass and coal). Also, SRWC can be harvested year-round, while grasses generally cannot be harvested once there is snow accumulation. This can create problems related to storage needed because of cyclical harvesting. Alternately, grasses regrow to relative fullness during the summer, meaning that if the biomass harvests are timed appropriately, there is little to no significant habitat disruption. Like SRWC, native grasses can thrive with relatively little cultivation after they are first established.

Land in the study area

Biomass plantations thrive as soil quality increases, but it is not feasible to seek out the highest quality farmland to grow energy crops. If we were to achieve 100 percent of Bay Front's 360,000 ton fuel need from SRWC and assuming 47 green tons/acre per the Minnesota Valley study, we would need to harvest 7,700 acres each year; assuming a five-year growing period, we would need 38,500 acres. While the goals presented in the Minnesota Valley study are aggressive, that is the scale needed to justify energy crops for power plant use. The assumptions in the Minnesota Valley study are reasonable, despite being predicated on technologies that are not yet commercially available.

Agricultural land use in the region is described in Tables 3 and 4.

Table 3. Farmland and cropland in study area, 2002

	Total county land area (acres)	Total county land area in farmland (acres)	Average farm size (acres)	Cropland (acres)	Harvested cropland (acres)	Non-harvested cropland (acres)
Ashland	668,103	58,746	259	29,353	22,536	6,817
Bayfield	944,902	111,851	239	59,867	44,490	15,377
Douglas	837,924	84,858	217	39,248	25,626	13,622
Gogebic	944,640	4,024	82	1,984	1,127	857
Iron	484,660	12,741	218	5,904	withheld	n/a
Sawyer	804,180	54,056	235	28,740	21,716	7,024
Total	4,684,409	326,726	--	165,096	115,495	43,697

Source: 2004. "2002 Census of Agriculture Volume 1, Geographic Area Series." Parts 22 and 49. US Department of Agriculture. Available online at http://www.nass.usda.gov/census/census02/volume1/mi/MIVolume104.pdf and http://www.nass.usda.gov/census/census02/volume1/wi/WIVolume104.pdf (accessed March 2007).

Table 4. Agricultural land cover in study area, 1997

	Total county land area (acres)	Percent of county land in farms	Percent of farmland in …		
			Cropland (non-pastured)	Pasture (all types)	Woods (non-pastured)
Ashland	668,103	7.0%	40.6%	22.4%	30.7%
Bayfield	944,902	8.9%	47.2%	19.7%	28.9%
Douglas	837,924	8.5%	33.2%	31.2%	29.1%
Gogebic	944,640	0.4%	*unavailable*		
Iron	484,660	2.0%	38.0%	16.8%	40.9%
Sawyer	804,180	6.0%	42.4%	29.9%	21.4%

Source: 1997. "Agricultural Land Cover by Wisconsin Counties." Program on Agricultural Technology Studies, Madison, Wis. Available at http://www.pats.wisc.edu/databook%20spreadsheets/Page03.htm (accessed March 2007)

The differences suggested by these charts indicate an increase in cultivated acres between 1997 and 2002.

By considering land use, we can consider scenarios where Xcel Energy tries to capture fractions of existing cropland. For instance, if five percent of all cropland in the study area were converted to SRWC, that would be 8,300 acres. If 50 percent of non-harvested cropland were converted to SRWC, that would be 22,000 acres.

The other critical factor in these scenarios is the land rental rates, which are shown in Table 5. The weighted average cash rent (based on the cropland listed in Table 3 and the rates in Table 5) is $18.50 per acre, and the unweighted average pasture rent (based only on the rates in Table 5) is $10.20 per acre.

Table 5. Soil rental rates, 2006

	Cash rent [$/acre]	Pasture rent [$/acre]
Ashland	18	15
Bayfield	15	12
Douglas	12	10
Gogebic	*unavailable*	
Iron	6	4
Sawyer	38	10

Source: 2006 Land Value Survey. Courtesy of Andrew Halada, Appraiser/Farm Loan Specialist, Wisconsin Farm Service Agency office, March 2007.

In addition to croplands, we want to consider uncultivated grasslands. Carl Beckman, USDA Farm Service Agency County Executive Director for Ashland County, suggests that at least 90 percent of managed non-croplands are currently harvested for hay to prevent them from reverting to brush (Beckman 2007). If we look at hay harvest numbers

in the region, then, we should have a conservative estimate of grassland acreage with active owners. (This is a different value from non-harvested cropland in Table 3, although there will be some overlap in cases where hay is being grown on non-harvested cropland.)

Table 6. Acres growing hay (all kinds), 2005

County	*Acreage*
Ashland	21,100
Bayfield	36,700
Douglas	29,100
Gogebic	1,025
Iron	3,000
Sawyer	14,200
Total	105,125

Source: USDA National Agricultural Statistics Service Statistics by State. Available at http://www.nass.usda.gov/Statistics_by_State/Wisconsin/index.asp (accessed March 2007), except Gogebic county, which is based on 2000 census data

This total acreage exceeds our estimate of what is needed to provide SRWC fuel to Bay Front. Hay grown in the study area is used for local livestock. Because the primary concern of the landowner is keeping the land somewhat cultivated, Beckman notes that landowners rent this land out for costs ranging from $5/acre to free, provided that the lessee harvests the hay. While SRWC grow best in the best soil, marginal croplands and grasslands can successfully support these crops, depending on the type of soil at the location. Soils throughout this region are catalogued by the USDA Natural Resources Conservation Service's Soil Survey Manuscripts (soils.usda.gov/survey/online_surveys), so specific locations can be researched as landowners express interest.

According to 2002 agricultural statistics, no short-rotation woody crops are being grown agriculturally in the study area, although test plots of crops such as hybrid poplar have been successfully established in the area.

CRP land in the study area

There is essentially no Conservation Reserve Program (CRP) land in our study area. Too little of this land has a history of cropping, so there is little incentive to use CRP to reduce cultivation (Butler 2007). Likewise, when the USDA offered a Grassland Reserve Program (GRP) in 2005, no or almost no acres in the study area were signed up (Peña 2007). The GRP rate offered was $5.50/acre for the Wisconsin counties in the survey area.[16] The Wisconsin FSA estimates that the majority of grasslands in the study area are primarily used for forage. The lack of CRP eligibility may make the landowner base in the study area especially receptive to SRWC cultivation as a minimal-effort way to make money off of grasslands.

[16] "Rental rates for rental agreements." USDA Natural Resources Conservation Service. Available online at http://www.wi.nrcs.usda.gov/programs/grp_rentalrates.html (accessed March 2007)

CRP lands cannot currently be used to harvest woody energy crops or to grow hybrid species, although some expect changes to these rules in future US Farm Bills.[17]

Potential production scenarios

We will consider various production scenarios, modeling our approach on the Minnesota Valley study as one of the most complete models for a power plant operation. SRWC used for fuel is a significantly different approach than growing trees for timber or fiber—those applications require wood with characteristics that could be incompatible with the closely spaced, short-lived planting model that could make power plants feasible. The following are the critical variables.

Tree spacing. We will consider 5.0 ft., 5.3 ft. and 8.0 ft. spacings. We will assume uniform biomass per tree over those spacings, but in reality, the trees tend to be larger when they are more closely spaced.

Tree size. The Minnesota Valley study cites 4.9 dry tons/acre as the expected annual growth for hybrid poplars with 5.3 ft. centers, with 1,551 plantings per acre (Ostlie 2003). This translates to 6.3 dry lb/tree-year, or 12.2 green wet lb/tree-year. After five years, this is 61 green lb/tree, or 47 tons/acre. If we assume this size for a poplar regardless of spacing, then at 5.0 ft. we will see 1742 trees, for 53 green tons/acre, and at 8.0 ft. we will see 680 trees, for 21 green tons/acre.

Land rent. We will use the weighted average crop rental rate of $18.50 per acre. If less desirable land is used, the rental rate should be less, although yield may also decline.

Annual costs. The Minnesota Valley study assumes $227/acre in costs in the first year for land preparation, planting and other start-up costs, and $66/acre in the second year (Ostlie 2003). Weed control costs are built into these numbers. No costs are included after year two.

Harvesting cost. With a rapid harvester, the Minnesota Valley study assumes $101/acre (Ostlie 2003). A cost estimate for other harvesting methods is $6.41/ton (Peterson 2006).

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[17] CRP contracts are mostly incompatible with energy crop cultivation. The CRP program does allow harvesting of grasses once every three years, but severely limits harvesting of tree stands. For instance, conifers can be grown at the same time that a landowner is trying to establish a hardwood tree stand, but when those conifers are harvested, the land loses its CRP status during that period. This practice is permitted, primarily because even after harvest, a hardwood tree stand remains. In Wisconsin, only native species can be grown on CRP land—although prior to implementation of this rule in the mid-‘90s, hybrid poplars were occasionally planted on CRP land.

The future of CRP programs is unclear. In the time that has elapsed between the 2002 Farm Bill and the pending 2007 Farm Bill, the opportunities presented by bioindustry have created an intense reevaluation of the value of farmland. In the short term, this is mostly driven by corn prices in excess of $4 a bushel. To the extent that SRWC and grasses are considered preferable to row cropping, the Farm Bill might be structured to promote such plantations.

Transportation and chipping costs. Given the 50 mile radius of our study area, the average transportation distance is 25 miles, as we assume a loaded cost of $1.70/mi, at a capacity of 27 green tons/load (Ostlie 2003). We will assume on-site chipping, since we are aware of interested providers of that service in the study area, but use of stationary chippers will increase the average transportation distance by the fixed distance between the chipper and the plant, and will put a higher value on lands near the chipping operation. Chipping is estimated at $4.27/green ton (Peterson 2006).

Table 7. Hybrid poplar production scenarios

	5.0' spacing	**5.3' spacing**	**8.0' spacing**
Spacing [inches]	60	63.6	96
Planting density [sq ft/tree]	25	28.1	64
Trees/acre	1742	1551	681
Tree growth [green lbs/tree-year]	12.2		
Land rent [$/acre]	18.50	18.50	18.50
Years	5	5	5
Yields [green tons/acre]	53	47	21
First-year costs [$/acre]	227		
Second-year costs [$/acre]	66		
Rapid harvesting costs [$/acre]	101		
Traditional harvesting costs [$/ton]	6.41		
Traditional harvesting costs [$/acre]	341	303	133
Shipping volume [green tons/loaded truck]	27		
Transportation cost [$/loaded truck-mile]	1.70		
Average distance [miles]	25		
Transportation cost [$/truck]	47.5		
Transportation cost [$/ton]	1.57		
Chipping cost [$/ton]	4.27		
Tons needed	360,000		
Total acres needed	6,774	7,611	17,342
Rapid harvesting			
Total cost [$/harvested acre]	487	487	487
Total cost [$/ton w/ transportation & chipping]	15.0	16.1	29.3
Traditional harvesting			
Total cost [$/harvested acre]	726	689	519
Total cost [$/ton w/ transportation & chipping]	19.5	20.4	30.8

These results indicate that SRWC are a promising avenue to pursue, and that a pilot plantation is fully warranted. When discussing a production-scale scenario, however, it seems very prudent to wait and see what happens with the Minnesota Valley facility and plantations. If the estimates of tons per acre and harvesting cost proposed by EPS for the Minnesota Valley facility are indeed achievable, then this is a wood source that is cost-competitive with current sources. Until that has been determined, however, other wood sources should pursued.

Conclusions

Source Summaries

Harvest Residues – The volume of these residues is estimated to be quite large but is not regularly collected. Collection, chipping and delivery of these residues are essential services which will be added to the cost of the fuel. Prices would need to be negotiated with individual logging operations, but some expressed optimism that an agreeable price per delivered ton of chips could be found that would enable them to expand their operations so they are capable of providing all of the 360,000+ tons of chipped treetops for use at Bay Front.

Primary Mill Residues – These are reportedly all being used (some for fuel at Bay Front), although some industry regulators believe this use is over-reported. The degree to which residues could be diverted from current uses to fuel for Bay Front is unknown, but under the most optimistic scenario would be less than 100,000 tons per year, and would involve substantial amounts in forms not ideal for use at Bay Front.

Secondary Mill Residues – The total volume of these and degree to which they are currently used for other purposes is unknown. However, given that they are more uniform in quality and have better fuel value than wetter primary mill residues, it is reasonable to assume they are at least as well used as primary mill residues.

Forest Thinnings – Although this category was not directly examined in this report, it should be noted that expansion in the demand for logging services through demand for chipped treetops would enable more active maintenance thinnings and selective cutting to improve the health of existing stands.

Hybrid Poplar Plantations – Plantations are very promising, but with a separate Xcel Energy facility already undertaking a commercial-scale plantation, it would be worthwhile to wait to see if those results meet expectations in terms of yield per acre and cost before committing similar resources. A pilot plantation is well-justified, and should be taken as an opportunity to identify specific parcels of qualified land in the study area.

Discussion

An increased appetite for biomass at Bay Front, such as would occur under a scenario eliminating the use of coal, would provide multiple opportunities for environmental and economic benefit to the surrounding region. Logging operations were hurt by recent pulp and paper mill closings and the commensurate drops in the demand for pulpwood. Many of these loggers see the opportunity to supply chipped treetops and slash to Xcel Energy as a way to expand their businesses and make more efficient use of their equipment, their time, and the trees they fell.

Removing treetops from sites they are currently logging does not involve making new roads or disturbing more land, and has few if any negative environmental consequences, and some marked aesthetic and regrowth benefits when done properly. Making these businesses stronger could provide a much needed boost to local economies and minimize

the loss of these industry specialists whose skills and knowledge will be much needed as our economy comes to rely more on biomass and less on fossil fuels.

Contracting with professional logging businesses for delivered wood chips will take advantage of their experience and expertise in negotiating stumpage contracts, harvesting, skidding, chipping and transporting fuel to the plant. The loggers want the same thing Xcel Energy wants: longer-term agreements for biomass with guaranteed prices. Some loggers interviewed were eager to speak with Xcel Energy representatives about this and were confident they would be able to expand their businesses to meet demand. They also stressed that the extractable biomass in the form of treetops, in more than sufficient quantities to meet the fuel needs of Bay Front, was being left on fields solely because of a lack of an established market.

The increase in demand for wood chips can also allow active sustainable forestry practices in situations where only sale of the traditionally "merchantable" timber would provide insufficient funding. This holds true especially for private landowners, who tend to default to "non-management" of their forest lands if they cannot afford to investigate and implement sustainable management practices such as selective thinning. The elevation of chipped treetops to "merchantable" status could also enable projects to move forward to clear cut stands to reestablish forests with native species.

Based on current land rents, one or more hybrid poplar plantations could be used to generate wood at a cost as low as $15 per ton, although these estimates should be adjusted as actual operating data from the Minnesota Valley plantations are available—this is likely to be at least five years out. Pursuing short-rotation woody crop plantations at a production scale means tackling such issues as species diversity, wildlife habitat and plant pathology, but current research indicates that these issues can be resolved to the satisfaction of most parties.

Finally, a less recognized benefit of Xcel Energy's increase in demand for wood chips would be the strengthening of the infrastructure needed for other incremental increases in production. Wood chips are currently used in the "Fuels for Schools" program and may act as the feedstock for biorefineries using advanced energy generation technologies such as biomass gasification or cellulosic ethanol. Establishing networks, strengthening existing core businesses, and enhancing biomass supply all are key steps in promoting transition to a healthy bioeconomy (Weitner et al. 2006).

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Attachment B3

(3 pages)

Assessment of Biomass Resources for Energy Generation at
Xcel Energy's Bay Front Generating Station
in Ashland, Wisconsin

Exhibit 4 to Direct Testimony of James K. Witt
Xcel Energy Bay Front Resource Assessment Update
June 2009

Before the Wisconsin Public Service Commission

Xcel Energy Bay Front Resource Assessment Update June 2009

Authors: Joe Kramer, Doug Ahl and Sean Weitner

This document updates and supplements the Energy Center of Wisconsin report titled "Assessment of Biomass Resources for Energy Generation at Xcel Energy's Bay Front Generating Station in Ashland, Wisconsin," (Kramer J, Weitner S, and Schutt P, 2007) (2007 Bay Front Study). The resources are characterized for counties largely within a 50 mile radius of the Bay Front plant including Ashland, Bayfield, Douglas, Iron, and Sawyer in Wisconsin, and Gogebic in Michigan.

I. Update of Harvest Residues Data

Data on harvest residues presented in the 2007 Bay Front Study were derived from the US Forest Service's Timber Product Output (TPO) report, which presents harvest data for the years 2000-2004 in annual generation estimates. (This data was provided as such by Ron Piva of the USFS North Central Research Station.) The Energy Center of Wisconsin converted the data from cubic feet to green tons.

We misidentified a source for one of our stated assumptions in the 2007 Bay Front Study. In the 2007 Bay Front Study, we indicated that we were assuming the average weight of a 128 cubic foot (ft^3) cord of wood residues (volume as stacked) to be 5,500 pounds, or 2.75 green tons (GT), and the weight of about 43 pounds per ft^3 (46.5 ft^3/GT) based on a study by Taras in 1956. When actually converting Forest Service ft^3 measures to GT, however, we assumed a weight of about 49.4 pounds per ft^3 and a cord weight of 6,320 pounds, or 3.16 GT (40.4 ft^3/GT) based on the findings of the 2006 Minnesota Logged Residue (Minnesota Study).[1] This number represents an average by all logging methods and harvest types from the sampled residues. Although we did not identify the Minnesota Study as the basis for the calculation, the Minnesota Study was actually and appropriately used in the 2007 Bay Front Study. The Minnesota Study is a superior source to the Taras study because the latter study focuses on tree species in the southeastern region of the US.

For this update, we reference the 2007 update to the Minnesota Study (issued by Minnesota Department of Natural Resources), and we further revise our methodology to use a *weighted* average that takes into account the number of sample sites by cover type used in that study. The weighted average value more accurately reflects the distribution of species within the sample areas.[2] Applying this method to the data provided in the 2007 update to the Minnesota Study yields an average ft^3/GT value of 39.7. In practice, the ratio of ft^3 of residues per GT will vary based on species actually harvested and other factors. In addition to applying the weighted average method as described above, we have conservatively

[1] The correct assumption was indicated on the Y axis of the graph in Figure 6 of the report showing county by county residue estimates.

[2] Although the application of the weighted average is more accurate for estimation purposes, the difference between the weighted average and the simple average is transcended by the (+- 15%) variation we adopted from the 2002 Hansen study and applied in our calculations in Section III below.

accounted for potential harvest volume variability by providing high and low range estimates at ±15 percent, or 45.7 and 33.7 ft^3/GT, respectively.

Using this new average density of 39.7 ft^3/GT, we have revised overall estimates of harvest residues for the 2000-2004 data used in the 2007 Bay Front Study as follows:

	2000-2004 (Annual)
Harvest Residues in ft^3	34,721,489
Harvest Residues in GT	874,597[3]

The new average density figure was also used to produce the updated 2007 figures reflected in the table in Section III below, which also reflect most recent update to the TPO, which presents 2007 harvest activity.

II. Other Removals

The authors have become aware of another category of potentially available biomass called "other removals" that is not included in the USFS harvest residue numbers, and that was not characterized in the 2007 Bay Front Study. "Other removals" are defined by the TPO Mapmaker V 1.0 as "unutilized wood volume of trees cut or otherwise killed by cultural operations (e.g. precommercial thinnings) or landclearings to nonforest uses. Does not include volume removed from the inventory by reclassification of timberland to productive reserved forest land." The category of other removals is included in this update because it could be a significant source of biomass in the region.

The authors have also become aware that additional biomass may be available from fuel reduction activities. "Fuel treatment thinnings" are defined as "standing and downed trees in overstocked stands that, if removed, would leave the stand healthier, more productive, and less susceptible to fire hazard" (Wilkerson et al. 2008). We are continuing to review how much biomass might potentially be available from this source.

III. Resource Calculations

Estimated harvest residues and other removals based on the TPO harvest numbers for 2007 are listed below.

Residues and Other Removals in Study Counties Based on 2007 Harvest Activity

	Cubic Feet	Gross GT (wt. avg.)	Gross GT (low, -15%)	Gross GT (high,+15%)	Retrievable GT (low, -15%)	Retrievable GT (high, +15%)	Alternative Retrievable GT (low, -15%)	Alternative Retrievable GT (high, +15%)
Harvest Residues	36,983,196	931,567	809,260	1,097,424	526,019 (65%)	713,326 (65%)	728,334 (90%)	987,682 (90%)
Other Removals	14,024,204	353,254	306,875	416,148	153,438 (50%)	208,074 (50%)		

[3] The 2007 study had listed 860,000 green tons of residues generated based on the 40.4 average cubic feet per green ton ratio.

Notes: Gross GT estimates assume a weighted average of 39.7 ft^3/GT. Cubic feet numbers for residues are from the US Forest Service Mapmaker program Version 1.0, data from 2007. Harvest residues are presented for both the 65% and 90 % retrievable assumptions.

The table also includes some alternate weight estimates using conversion ratios of 15 percent above and 15 percent below our weighted average. The range of ±15 percent was chosen based on a comparison of Lake States FIA volume data to national estimates (Hansen 2002). Not all of the gross estimated quantities of biomass will be technically retrievable. The values used in literature to represent the proportion of harvest residues that is technically retrievable range from 65 percent (Wilkerson et al. 2008) to 90 percent (McKeever and Falk 2004). In addition, the retrievable portion of the "other removals" category has been assumed to be 50 percent (Wilkerson et al. 2008). Estimates are given in the table above using these proportions.

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ATTACHMENT C
Bay Front Boiler #5 Gasifier Project
Alternatives Analysis

In preparing this Application, the economic and qualitative analysis included a review of the following Project alternatives using our strategist model:

1) Market Purchase Option: Continue to burn coal in boiler #5 until 2015, then retire boiler #5 and replace it with market-based energy and capacity;

2) Wind Option: Retire boiler #5 and replace it with wind resources located in Minnesota or the Dakotas;

3) Circulating Fluidized Bed Option: Replace boiler #5 with a boiler using circulating fluidized bed ("CFB") technology; and

4) Natural Gas Conversion Option: Continue burning coal in boiler #5 until 2015 then switch to 100 percent natural gas for the remaining life of the boiler, and run the boiler as a natural gas peaking resource.

Strategist

To evaluate the economic costs and benefits of the alternatives, Xcel Energy utilized the Strategist resource-planning model. Xcel Energy uses Strategist to model the load and generation resources for the entire NSP System, in Resource Planning and Certificate of Need proceedings. The model produces a long-range forecast of total system costs. Planners then compare the forecast costs for the various alternatives under consideration.

The Strategist model consists of four primary components:

Load Module: This module contains the NSP System load forecast, load management resources, and conservation programs. It produces long-range estimates of the NSP System's hourly load, net energy requirements, and annual peak load.

Generation Module: This module contains the operating costs and performance characteristics for our thermal units, renewable resources, and energy transactions. It uses an hourly dispatch simulation to estimate how customer demand will be met and what the associated costs and emissions will be.

Capital Project Module: This module estimates the revenue requirements for capital projects. It keeps track of rate base, depreciation, taxes, and rate of return.

Expansion Planning Module (Proview ™): This module uses a dynamic programming algorithm to derive the least-cost combination of possible new generation resources. It calculates the ratepayer and societal costs for thousands of different resource combinations to arrive at a least-cost plan.

a. Strategist Input Assumptions

The inputs used in Strategist represent the Company's best estimate of future conditions at the time of the filing. By their nature, forecasts are imprecise and can be the subject of reasonable disagreement. To mitigate forecast and assumption uncertainty, the Company employs sensitivity analyses to test the impacts of input. Each of the major inputs and how the Company employed them in the analysis are discussed next.

(1) Generation Resources

In Strategist, the Company models all the generation resources in the NSP System. The operating characteristics are based on historical data and modified to reflect any planned changes to the units.

(2) Load Forecast

The load forecast used in the Company's analysis is based on historical data but also integrates the expected impact of the recent economic contraction on consumer demand. Both a low load growth and a high load growth scenario were used to test the sensitivity of the model results to the load forecast.

(3) Fuel Cost Forecasts

The Company uses a variety of resources to develop our long-range fuel cost forecast, including both publicly available data and competitively sensitive information not available to the public. In Strategist, the Company varied its natural gas and coal forecasts by plus and minus 20% to test model sensitivity. For the biomass alternatives at Bay Front, the Company varied the cost of biomass fuel by +40%, +20%, -20% and –40% to test the impact of the fuel cost assumption on the overall economics of the alternatives.

(4) Other Input Assumptions

Another Strategist input that is important to the evaluation of the Project is the federal production tax credit ("PTC") for renewable energy resources. The PTC for biomass is assumed to be $20/MWh escalating at 2% and extended through 2015. As a sensitivity, the Company also ran the model with the PTC expiring in 2009.

One of NSP's resource planning philosophies is to plan for future needs as if the NSP System were a stand-alone system. This approach ensures that the Company will meet the needs of our customers regardless of developments elsewhere in the market. However, since the launch of the MISO energy market, the operation and costs of the NSP System have been intertwined with all of the NSP System's neighboring utilities. Thus, when the Company ran the Strategist model, all interactions with the MISO market were turned off, and only NSP units and firm bilateral transactions were used to meet customer demand. As a sensitivity, market interactions were turned on and the model was allowed to purchase energy from or sell excess energy to the market.

Strategist Results

The following tables summarize the strategist results for the baseline assumptions and the sensitivity analysis. Among the alternatives analyzed, the CFB Option is the most costly alternative.

The Market Purchase Option was used as our baseline. However, we cannot capture some of the inherent difficulties associated with market purchases because Strategist is not an hourly dispatch model. Both the Market Purchase and Natural Gas Conversion Options have relatively lower up-front capital costs but depend on natural gas or market energy to meet customer needs. These alternatives can make economic sense when using current economic forecasts, but actual costs will be higher than expected if natural gas and market energy prices spike or grow faster than expected.

Table 1 - Strategist Results – Baseline Assumptions

	Market Purchase	CFB	Wind	Natural Gas Conversion	Gasifier Option
PVRR ($millions)	$55,867	$56,010	$55,916	$55,867	$55,925
Difference From Status Quo		+ $144	+ $69	$0	+ $58
Gasifier Plus 10% Capital Cost					+ $66
Gasifier Plus 20% Capital Cost					+ $74

Table 2 - Strategist Sensitivity Analysis

PVRR ($millions)	Market Purchase	CFB	Wind	Natural Gas Conversion	Gasifier Option
Baseline Assumptions	$55,867	+ $144	+ $49	$0	+ $58
Gasifier Plus 10% Capital Cost	$55,867	+ $144	+ $49	$0	+ $66
Gasifier Plus 20% Capital Cost	$55,867	+ $144	+ $49	$0	+ $74
Low Load Growth	$53,568	+ $145	+ $52	- $(1)	+ $59
High Load Growth	$58,258	+ $143	+ $47	$0	+ $58
Gas + 20%	$57,809	+ $128	+ $43	-$(0)	+ $52
Gas - 20%	$53,950	+ $158	+ $56	$0	+ $64
Coal + 20%	$56,969	+ $138	+ $47	- $(0)	+ $55
Coal - 20%	$54,775	+ $149	+ $51	- $(0)	+ $62
B.F. Biomass + 40%	$55,867	+ $183	+ $49	$0	+ $77
B.F. Biomass + 20%	$55,867	+ $163	+ $49	$0	+ $68
B.F. Biomass - 20%	$55,867	+ $124	+ $49	$0	+ $49
B.F. Biomass - 40%	$55,867	+ $104	+ $49	$0	+ $39
MISO ON	$55,816	+ $139	+ $43	- $(1)	+ $57
PTC Expire EOY 2009	$56,328	+ $144	+ $71	- $(0)	+ $71