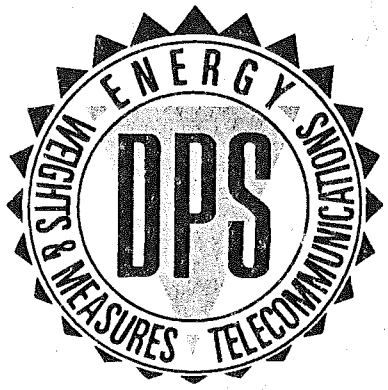
NORTHERN STATES POWER COMPANY'S PRAIRIE ISLAND NUCLEAR FACILITIES: AN ANALYSIS OF OPTIONS



PREPARED BY
MINNESOTA DEPARTMENT OF PUBLIC SERVICE

FEBRUARY 1994

EXECUTIVE SUMMARY

BACKGROUND

The Department of Public Service (Department) has completed an investigation into the costs of shutting down Northern States Power Company's (NSP) nuclear generating units at Prairie Island. The Department conducted this analysis to meet the growing informational needs of the Minnesota Legislature and the general public regarding this issue.

The Department evaluated the costs of replacing Prairie Island with:

- fossil-fuel resources;
- biomass resources; or
- a mixture of wind and biomass resources.

The Department used a social-cost approach to evaluate the above three alternatives. Thus, the Department considered the internal and environmental costs of each alternative.

The Department also considered the potential impact of deteriorating operating conditions at Prairie Island. (NSP's recent law suit against Westinghouse Corporation raised questions about these impacts.) Finally, the Department evaluated the effects of an early shutdown of Prairie Island on Minnesota's overall economy.

CONCLUSIONS

Based on this analysis, the Department concludes that:

- All three options are financially and environmentally inferior to continued operation of Prairie Island.
- If Prairie Island must be shut down, replacement with fossil fuel is the cheapest alternative from a social-cost perspective.
- Replacement of Prairie Island with renewable technologies, either biomass or a mixture of biomass and wind, will cost approximately twice as much on a social-cost basis as replacement with fossil-fuel technologies.
- An early shutdown of Prairie Island would also affect Minnesota's economy, reducing gross state product by $342 million by 2008.

Finally, while the evidence indicates little deterioration to date, the Department found that potential deteriorating operating conditions at Prairie Island could, if realized, cost as much as $383 million in social costs.[1] However, even if these costs are realized, none of the Department's conclusions regarding shutdown of Prairie Island are altered.

[1] In the Department's investigation into the effect of this issue on our analysis in the Certificate-of-Need proceeding, the Department relied on its original external cost assumptions used in the Certificate-of-Need proceeding. In the current analysis, the Department relies on the external cost estimates recommended by the Department in the Public Utilities Commission's investigation into the evaluation of the environmental costs of electricity production. Therefore, the potential $383 million in social costs is based on the Department's most recent external cost estimates.

I. INTRODUCTION

As part of its review of Northern States Power Company's integrated resource plan (IRP), the Minnesota Department of Public Service continued its investigation and analysis of issues related to NSP's proposed Independent Spent-fuel Storage Installation (ISFSI) at its Prairie Island nuclear generating plant. The Department's IRP comments included an initial study of the potential costs of shutting down the Prairie Island nuclear units. In addition, the Department reported on the potential financial effects of possible deteriorating operating conditions at Prairie Island and the Monticello nuclear facilities. Finally, the Department recommended specific actions that NSP should take to minimize the potential costs of these contingencies.

Because the Department considered this analysis to be a preliminary effort to outline the risks related to NSP's nuclear units, we conducted further analysis, including:

- estimating the environmental costs of contingencies related to the Prairie Island units and adding them to our preliminary analysis;
- estimating the social cost of using renewable-energy resources to replace nuclear generation and meet new load growth;
- estimating the impact a potential shutdown could have on the Minnesota economy; and
- developing additional refinements of our initial analysis.

To conduct this additional analysis, the Department developed three scenarios for replacing Prairie Island and estimated a range of costs for each. We then compared the costs of each scenario to a "base case," where Prairie Island continues to operate until the end of its operating licenses, and additional future needs are met primarily with fossil-fuel generation. This base-case scenario reflects the costs to NSP's ratepayers should the Minnesota Legislature allow NSP sufficient storage to continue planned operation of Prairie Island and NSP meets its future needs according to its current proposed IRP.

The Department notes that some of the assumptions used in our analysis were made for illustrative purposes to gain insight into a complex set of contingencies. This analysis should not be seen as the Department's recommended plan for potential replacement of Prairie Island. Instead, it provides an estimate of the range of potential costs posed by the various scenarios. In providing this analysis, the Department intends that readers will receive information regarding the costs surrounding NSP's request for additional storage for nuclear waste.

Because NSP's proposal for an ISFSI at Prairie Island is before the Minnesota Legislature and generating substantial public interest, the Department believes that its analysis should be easily available to all interested parties. Therefore, we will provide this analysis to members of the Minnesota Legislature and interested parties.

II. NSP'S FUTURE NEEDS

Prairie Island Shutdown Contingency

NSP operates two nuclear units at its Prairie Island station. Each unit has an accredited capacity of 530 MW. Together they currently supply about 23 percent of NSP's annual energy requirements. Although the original operating licenses of these plants are not due to expire for about another 20 years, NSP has exhausted its ability to store spent fuel on-site. Until the federal government begins removing spent fuel and storing it elsewhere, NSP has two alternatives: provide additional spent-fuel storage on-site (subject to a Certificate of Need (CON) from the Minnesota Public Utilities Commission (PUC) and Legislative approval) or shut down the two units. The Minnesota Legislature will soon deal with the question of additional on-site storage of spent fuel. Until this issue is resolved, NSP faces great uncertainty.

Additional Resource Needs

In addition to the uncertainties surrounding Prairie Island, NSP must obtain new resources to meet growing demand. By 2008 NSP will require about 2,500 MW of new resources, not including potential replacement of Prairie Island. Including replacement of Prairie Island, NSP will require about 3,600 MW of new resources by 2008. These required resources supplement the 2,116 MW of Demand-Side Management (DSM) the Company expects to achieve by 2008. NSP will achieve this 2,116 MW through a combination of load management and strategic conservation, targeting a variety of electrical end-uses including lighting, cooling, refrigeration, and industrial processes. (A detailed description of NSP's planned DSM activity can be found in the Company's Conservation Improvement Program.)

NSP intends to meet the required additional resources primarily through a competitive-bidding process. All supply-side resources, including renewable resources, will have an opportunity to participate in this process. All bids will be evaluated on the basis of the total costs they impose on society, including environmental costs. NSP's proposal for a competitive-bidding approach is currently before the PUC.

III. DEPARTMENT OF PUBLIC SERVICE'S REPLACEMENT COST ANALYSIS

To further assess the impacts a potential shutdown of Prairie Island will have on Minnesota and NSP's ratepayers, the Department analyzed three potential scenarios:

- Scenario A: Shut down Prairie Island units 1 and 2 in 1995, and meet future needs primarily with traditional fossil-fuel generation.
- Scenario B: Shut down Prairie Island units 1 and 2 in 1995, and meet all future needs with a biomass technology.
- Scenario C: Shut down Prairie Island units 1 and 2 in 1995, and meet all future needs with a mixture of wind power and biomass technology.

The Department also considered replacing Prairie Island with energy from Manitoba Hydro. However, Manitoba Hydro will not have significant amounts of additional energy available until well beyond 2000. Further, significant increases in energy purchases would require construction of new transmission capacity in Minnesota. Given these facts, the Department did not conduct a replacement cost analysis based on additional energy purchases from Manitoba Hydro.

The Department's approach to this analysis and a description of these scenarios follow.[1]

A. Social-Cost Approach

The Department has consistently supported the use of a social-cost approach when considering the addition of new energy resources. Therefore, for both the base case and each replacement scenario, the Department provides estimates of both internal and external costs.

Internal costs reflect the private investment needed to construct and operate the energy resource. External costs reflect the additional costs posed by the energy resource, but not directly captured in any monetary exchange. The main external costs of energy resources are environmental costs. The Department estimates the external costs of each scenario by considering the effects of the following six air emissions:

- sulfur dioxide;
- nitrous oxide;
- particulates;
- carbon dioxide;
- volatile organic compounds; and
- mercury.

The Department's analysis also values the external benefits of reduced radioactive emissions caused by shutting down Prairie Island. While we recognize that these are not the only by-products of electric generation that impose social costs, they are the most prominent and most readily quantified.

---

[1] The Department also considered the possibility of operating Prairie Island at reduced levels, thus extending its useful life without constructing the ISFSI. However, the Department found this option to contain no advantages over a full shutdown of Prairie Island. By operating Prairie Island at reduced levels, NSP would still need to purchase significant amounts of expensive energy on the wholesale market, thus exposing NSP to increased market risks and ultimately increased costs. Since the costs of this "stretch out" alternative do not differ significantly from the cost of a more-immediate replacement option, we did not separately analyze it here.

The Minnesota Public Utilities Commission is currently considering the valuation of the environmental costs of electricity production and will establish interim values for selected emissions by March 1, 1994. The Department bases the environmental costs used in this analysis on its recommendations made to the Commission in its current proceeding.

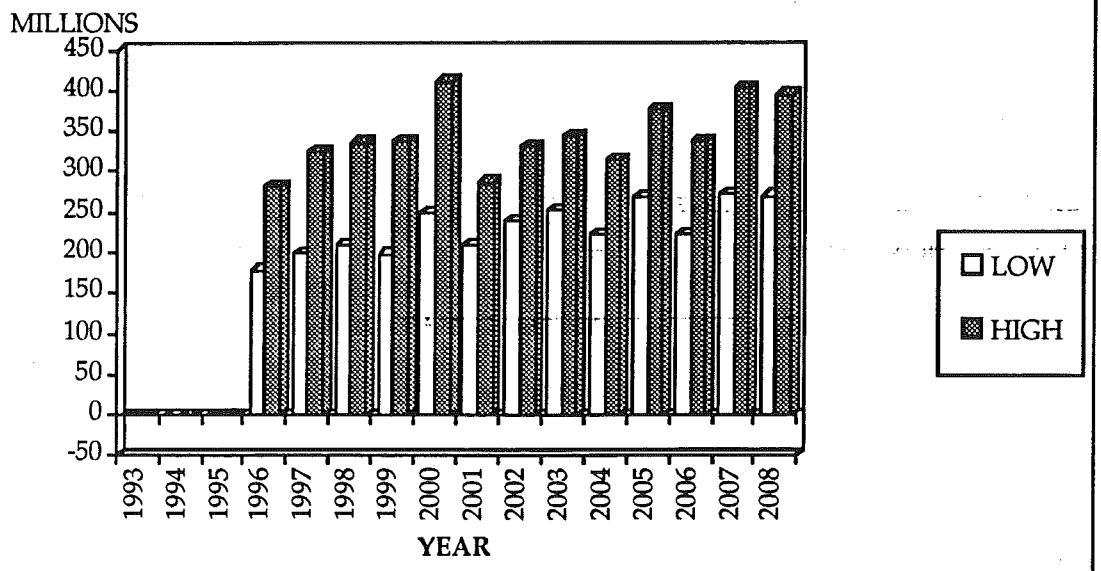
B. Scenario A: Replacement with Fossil-Fuel Generation

In the fossil-fuel scenario, the Department assumes that NSP is forced to shut down Prairie Island at the end of 1995 and replace it with gas-fired generating units. Additionally, this scenario assumes that NSP meets all new resource needs identically to NSP's base-case plans; that is, new resource needs are primarily met with fossil-fuel resources, including gas- and coal-fired units. The scenario further assumes that NSP can construct gas-fired generating units to replace Prairie Island by 1999. In the interim period (1996 through 1998) NSP must purchase replacement capacity and energy from the wholesale market. A list of key assumptions related to this scenario is provided in Attachment 1.

The Department expects the fossil-fuel scenario to increase social costs (internal plus external costs) by $1.6 to $2.4 billion (1993 dollars) over the base case.[2] The Department provides a cost range to incorporate uncertainty related to the timing and cost of resources used to replace Prairie Island. Chart 1 shows the annual social cost increases resulting from the fossil-fuel scenario.

[2] The Department previously estimated the internal costs of the fossil-fuel scenario to be in the range of $1.0 to $1.8 billion. The Department has revised this estimate to correct for a small modeling discrepancy the Department discovered subsequent to issuance of its initial analysis. The Department now estimates an internal cost range for the fossil-fuel scenario of $.948 billion to $1.74 billion. The Department notes that this small correction does not alter any of the Department's conclusions regarding Prairie Island.

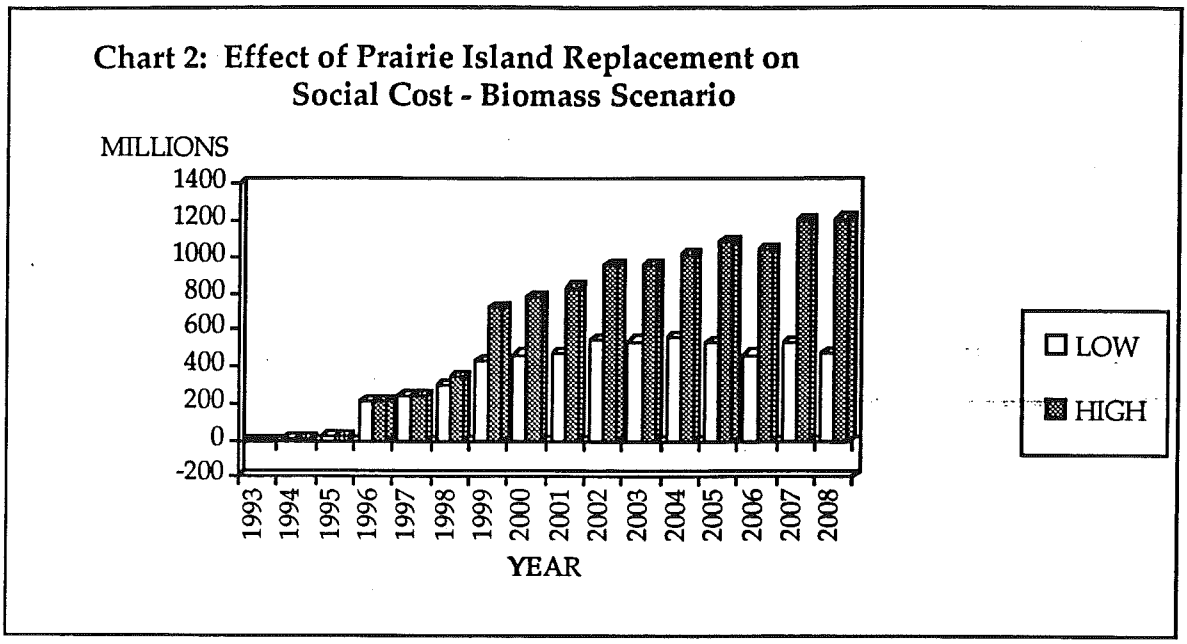
Chart 1: Effect of Prairie Island Replacement on Social Cost - Fossil-Fuel Scenario



C. Scenario B: Replacement with Biomass Technology

In the biomass scenario, the Department assumes that NSP is forced to shut down Prairie Island at the end of 1995 and replace it with a whole-tree burning technology. The Department chose the whole-tree burning technology as a proxy for biomass technologies, as its costs are most certain at this time and it appears to be one of the lower-cost biomass technologies available. Further, since it would be contrary to a least-cost planning approach (based on social costs) to replace a nuclear plant with renewable resources but meet future needs with fossil-fuel resources, the Department assumes that all additional resource needs (those needed beyond replacement for Prairie Island), other than peaking needs, are met with the whole-tree technology. This assumption recognizes that, from a social-cost perspective, Prairie Island is a lower-cost resource than a coal-fired plant. A list of key assumptions related to this scenario is also provided in Attachment 1.

The Department estimates the biomass scenario will increase social costs by $2.8 to $4.9 billion (1993 dollars) over the base case. The Department provides a cost range to incorporate uncertainty related to the cost of the whole-tree technology. Chart 2 shows the annual cost increases resulting from the biomass scenario.



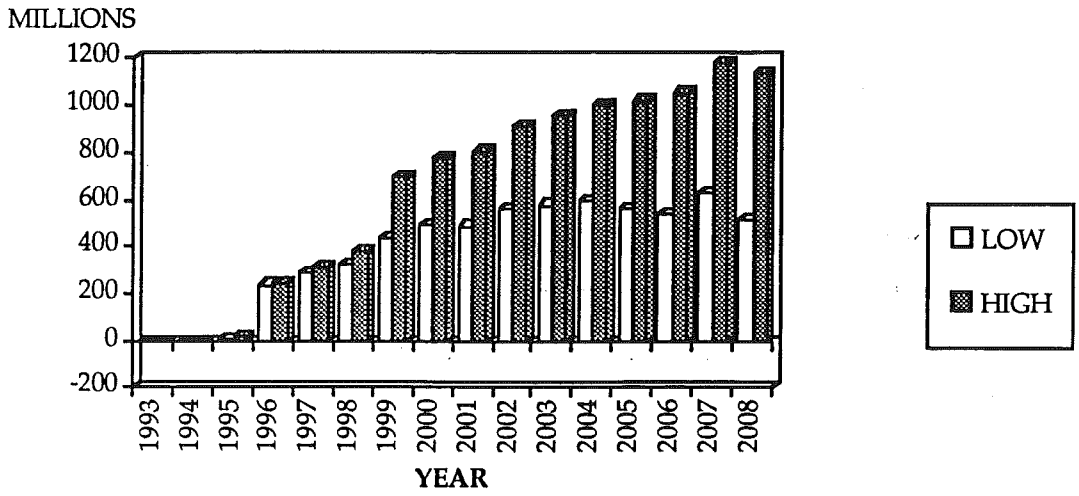
D. Scenario C: Replacement with Wind and Biomass Technology

In this scenario, the Department assumes that NSP is forced to shut down Prairie Island after 1995 and replace it with a combination of wind and biomass resources. As in the biomass scenario, this analysis also assumes that all new resources other than peaking needs are met with a combination of wind power and biomass. This scenario has NSP adding 300 MW per year of wind power beginning in 1997, totaling 3,600 MW by 2008.[3] NSP would then meet any resource needs not met by wind power (970 MW by 2008) with biomass. The Department again uses the whole-tree burning technology as a proxy for biomass costs. Attachment 1 lists the key assumptions related to this scenario.

The Department estimates the wind/biomass scenario to increase social costs by $3.0 to $4.8 billion (1993 dollars). The Department provides a cost range to incorporate uncertainty related to the costs of the wind and biomass technologies. Chart 3 shows the annual cost increases resulting from the wind/biomass scenario.

[3] 3,600 MW represents the name-plate capacity of the wind turbine. However, due to the intermittent nature of wind, the 3,600 MW will provide only 900 MW of peaking capacity. This 25 percent accreditation is based on the Department's discussion with Mid Continent Area Power Pool (MAPP).

Chart 3: Effect of Prairie Island Replacement on Social Cost - Wind Scenario



E. Comparative Analysis

Each of these scenarios impose significantly greater social costs than continued operation of Prairie Island; the most optimistic figure is $1.6 billion over the costs of continued operation. However, by comparing the three replacement-cost scenarios, we can make observations about which will most effectively meet least-cost planning goals, should NSP be forced to shut down Prairie Island. Table 1 compares the social costs of each scenario.

TABLE 1

COMPARISON OF REPLACEMENT COSTS OF PRAIRIE ISLAND

(Millions of Dollars)
Present Value Social Costs

	Internal Costs (1993 Dollars)	External Costs (1993 Dollars)	Total Costs (1993 Dollars)
Fossil Fuel			
Low	$982	$617	$1,599
High	$1,744	$625	$2,369
Biomass			
Low	$2,711	$131	$2,842
High	$4,759	$139	$4,898
Wind & Biomass			
Low	$2,973	$31	$3,004
High	$4,811	$29	$4,840

Table 2 summarizes the potential rate impacts of shutting down Prairie Island on NSP's customers. Please note that these figures include only the internal costs of a shutdown. Inclusion of the external effects would obviously increase these figures. The average rate increase under the fossil-fuel scenario is comparable to the average rate increase NSP has been granted in recent general rate proceedings. The rate impacts for the biomass and wind scenarios would be approximately two and one-half times as great as recent rate increases. Finally, the Department notes that the absolute effects on an average industrial user's bill would be far larger than the impact on a residential customer, since industrial users purchase greater amounts of electricity annually.

TABLE 2

RATE IMPACT OF PRAIRIE ISLAND SHUTDOWN

	Percent Increase	Effect on Annual Residential Bill
Fossil Fuel		
Low	3.5%	$18.56
High	7.0%	$37.11
Biomass		
Low	9.7%	$51.43
High	17.0%	$90.13
Wind & Biomass		
Low	10.6%	$56.20
High	17.1%	$90.66

The Department believes that the following observations are critical to an informed analysis of alternatives:

- If Prairie Island must be shut down, replacement with fossil fuels is the cheapest alternative from a social-cost perspective.

- Replacement of Prairie Island with renewable technologies, either biomass or a mixture of biomass and wind, will cost approximately twice as much on a social-cost basis as replacement with fossil-fuel technologies.

- Market forces are the primary cause of uncertainty with respect to replacement with fossil fuels. Fluctuations in the prices of fossil fuels (natural gas or coal) and purchased power are the sources of this uncertainty.

- Technological uncertainty is the primary cause of uncertainty in the renewable-technology scenarios. Both wind and biomass represent relatively new technologies and entail new risks related to construction and operating costs.

Finally, the Department notes that all three scenarios are environmentally inferior to continued operation of Prairie Island; that is, all three scenarios will increase the external costs of electricity generation. Some may find this result surprising,

particularly given that the analysis placed value in reduced accumulation of radioactive wastes. Nonetheless, due to the increased air emissions entailed in the fossil-fuel and renewable scenarios, shutting down Prairie Island will increase environmental costs. Thus, while the Department favors increased reliance on renewable resources, we view this issue as distinct from the decision the Legislature must make regarding Prairie Island.

The Department believes that renewable resources will play a significant role in Minnesota's energy future. Renewable energy will become more cost-effective as technological improvements continue to develop. Further, renewable energy can play important roles in meeting certain energy requirements. Therefore, the current analysis should not be seen as a critique of renewable-energy resources. Rather, it should be seen as confirmation that a variety of energy resources should play a role in our energy future. A list of renewable energy projects supported or implemented by the Department is provided in Attachment 2.

F. *State Economic Impacts*

To estimate state economic impacts of a potential shutdown of Prairie Island, the Department used Energy 2020, a regional planning model, to model these effects through the year 2020. Based on this analysis, the Department expects the early shutdown of Prairie Island to reduce Minnesota's gross state product by the year 2008 by about $342 million, or a .09 percent reduction in gross state product.

The Department notes that it has not estimated the effect of shutting down Prairie Island on state employment. These employment effects may differ among the three scenarios considered above. For example, replacement of Prairie Island with renewable resources may enhance local energy-related employment. However, this must be weighed against the employment dampening affects of a reduced state domestic product.

G. *Effects of Deteriorating Unit Performance*

NSP's recent lawsuit against Westinghouse Corporation has raised concerns regarding the future reliability and cost-effectiveness of the Prairie Island units. The Department conducted an investigation of this issue and analyzed the potential costs to NSP and its ratepayers. Based on this investigation, the Department concludes that NSP may potentially incur costs of up to $383 million in social costs (1993 dollars) due to performance problems with the Prairie Island units.[4] (The Department's complete investigation into this issue is also available for review.) Since these potential costs increase the cost of the base-case scenario, they correspondingly reduce the costs of the replacement scenarios.

---

[4] In the Department's investigation into the effect of this issue on our analysis in the Certificate-of-Need proceeding, the Department relied on its original external cost assumptions used in the Certificate-of-Need proceeding. In the current analysis, the Department relies on the external cost estimates recommended by the Department in the Public Utilities Commission's investigation into the evaluation of the environmental costs of electricity production. Therefore, the potential $383 million in social costs is based on the Department's most recent external cost estimates.

While the costs of potential deteriorating plant performance affect the analysis of the replacement costs of Prairie Island, they do not change any of the Department's conclusions in this document. Even if the entire $383 million were incorporated into each replacement-cost scenario, they will still entail higher social costs than continued operation of Prairie Island. Further, the relative ranking of the replacement scenarios will not change. Rather, the social cost of each scenario will fall by $383.

In conclusion, the potential performance problems referenced in NSP's suit against Westinghouse does not alter the Department's conclusions in its analysis of the costs of replacing Prairie Island, although they would lessen the rate and economic impacts of a potential shutdown.

IV. CONCLUSION

Minnesota's energy, environmental, and economic future will clearly and dramatically be influenced by the decisions made regarding Prairie Island. As shown above, NSP's ratepayers will pay higher rates if NSP is forced to shut down Prairie Island. The magnitude of the rate increase will depend on the choice of replacement technology.

Minnesota's environment will also be negatively impacted by shutting down Prairie Island, regardless of the chosen replacement technology. The environmental impact can be minimized by a total commitment to renewable resources. However, as explained above, the environmental cost savings do not offset the higher investment costs; thus, the renewable energy scenarios impose a higher social cost than the fossil-fuel scenario.

Finally, the rate impact on NSP's customers will ripple through Minnesota's economy. Minnesota will experience a $342 million reduction in gross state product if Prairie Island is shut down.

The Minnesota Legislature faces difficult decisions regarding the continued operation of Prairie Island and Minnesota's energy and economic future. All options are costly. The Department provides this analysis to contribute to an informed discussion of these issues.

Attachment 1

MINNESOTA DEPARTMENT OF PUBLIC SERVICE
ANALYSIS OF POTENTIAL PRAIRIE ISLAND SHUTDOWN
CRITICAL MODELING ASSUMPTIONS

I. FOSSIL-FUEL SCENARIO

- Prairie Island is shut down after 1995.
- NSP replaces Prairie Island with power purchases through 1998.
- NSP constructs gas-fired generation to begin operation in 1999.
- Future load growth is met primarily through additional coal- and gas-fired generation.

II. BIOMASS SCENARIO

- Prairie Island is shut down after 1995.
- NSP replaces Prairie Island with power purchases through 1998.
- NSP constructs whole-tree generation to begin operation in 1999.
- Future load growth is met primarily with whole-tree fired generation.

Assumed Costs of Whole-Tree Generation
(1993 Dollars)

	Low-Cost Scenario	High-Cost Scenario
Capital Cost	$1,178/kW	$1,432/kW
Fuel Cost	$1.75/MBTU	$3.75/MBTU
O&M Cost	$3.74/MWH	$3.74/MWH

III. WIND SCENARIO

- Prairie Island is shut down after 1995.
- NSP replaces Prairie Island with power purchases through 1998.
- NSP constructs wind generators at a rate of 300 MW/year, beginning in 1997.

- NSP constructs whole-tree generation to begin operation in 1999.
- Future load growth is met primarily with a combination of wind- and whole-tree-fired generation.

Assumed Costs of Wind and Whole-Tree Generation
(1993 Dollars)

Whole Tree

	Low Cost	High Cost
Capital Cost	$1,178/kW	$1,432/kW
Fuel Cost	$1.75/MBTU	$3.75/MBTU
O&M Cost	$3.74/MWH	$3.74/MWH

Wind

	Low Cost	High Cost
Capital Cost	$842/kW	$1,250/kW
O&M Cost	$7.50/MWH	$10.00/MWH
Average Capacity Factor	30%	30%
MAPP Capacity Accreditation	25%	25%

MINNESOTA DEPARTMENT OF PUBLIC SERVICE
SUSTAINABLE ENERGY INITIATIVES

Minnesota is rich in the renewable energy resources of wind and biomass. The Minnesota Department of Public Service, through a variety of initiatives, seeks to evaluate and help develop these resources, which have potential benefits for both Minnesota's environment and economy.

WIND

- *Northern States Power and Otter Tail Power Wind Projects.* Steps to incorporate wind-based electric generation into their power sources have been taken by Northern States Power and Otter Tail Power. The steps came as a result of action by the Department in overseeing utility Conservation Improvement Programs (CIP) and in evaluating utility proposals for meeting future demand (what are called Integrated Resource Plans, or IRP). At the urging of the Department, NSP committed to developing a 100 megawatt wind farm in southwestern Minnesota and will have the first 50 megawatts installed by 1995. The Department also called for Otter Tail Power to develop a 30 megawatt pilot wind project. As a first step, the Department ordered the utility to invest CIP funds in a study of wind power potential to determine the best location for installing an initial 10 megawatts of power.

- *Wind Resource Assessment Project (WRAP)* is a cooperative effort by electric utilities and the Department to document Minnesota's wind power potential. More than 10 years of collecting wind speeds, direction, duration, and other pertinent data at sites around the state have established a data base and map defining Minnesota areas on the basis of their wind energy potential. The Department is expanding the number of WRAP sites and also has increased its analysis capabilities. The Department can now calculate approximate electrical energy production for specific turbines available on the market and provide utilities with accurate comparisons of wind energy availability for a particular site with electrical demand for the area.

- *Wind-Solar Power Correlation Study.* Daily and seasonal fluctuations in wind power affect wind power availability and therefore limit its potential as a replacement for baseload power plants. The Department, with funds from the U.S. Department of Energy and Northern States Power, is studying the correlation of solar power with wind power to determine if solar electric systems could provide power during periods of low wind availability.

- *School Wind Energy Project.* Wind machines will be installed at four Minnesota school sites over the next four years, providing a portion of the schools' electric energy needs and also serving as the focus of a science education curriculum. The Department applied for and received federal funds to help pay for the cost of the machines. If they prove effective in reducing the schools' energy costs, the Department will encourage other schools to finance installation of wind machines through the Department's Energy Investment Loan Program.

- *Proposed Utility-Government Wind Development Partnership.* The Department has asked the Legislative Commission on Minnesota Resources to consider a project that would establish a cooperative partnership between government and unregulated utilities to accelerate wind generation. Under the project, a minimum of one megawatt of wind power production capacity would be installed at participating cooperative and municipal electric utilities. The project would give smaller utilities an opportunity to gain experience in using wind power and would also add to our information on Minnesota's wind resource.

BIOMASS

- *Whole-Tree Burning Study.* The Department approved a proposal by Minnesota Power to conduct a preliminary study on the feasibility of generating electricity with a whole-tree burning technology.

- *Ethanol E-85 Demonstration Fleet.* The State of Minnesota is assessing the technical and practical feasibility of using E-85, a fuel composed of 85 percent ethanol and 15 percent gasoline, in alternative fuel vehicles. The Department of Public Service, with a grant from the Council of Great Lakes Governors, works closely with other state departments in operating ten 1993 Chevrolet Luminas that are factory equipped with a computer chip which adjusts the ignition and fuel system automatically, allowing them to run on any mixture of gasoline with up to 85 percent ethanol. The Department collects and analyzes all technical data associated with the project, including fuel consumption, vehicle performance, driver satisfaction, and vehicle emissions. (The State also operates another 20 E-85 vehicles that are not a part of this grant.) The Department also contributed grant funds to construction of an E-85 fueling station to serve the State's E-85 fleet.

- *E-85 Network.* To expand use and knowledge of E-85 fuel, as well as enable the state fleet of E-85 vehicles to re-fuel outside of the metropolitan area, the Department over the next four years will select four communities to participate in an E-85 network. The cities will purchase at least three alternative fuel vehicles capable of running on E-85 and also will install an E-85 storage tank. The Department, with federal funds, will provide matching grants to the cities for the cost of the project.

- *High Concentration Ethanol Fuel Study.* The Department applied for and received a Council of Great Lakes Governors grant to support a Mankato State University study comparing operations of a standard car using gasoline and a car converted to run on fuel with a high percentage of ethanol – from 50 to 85 percent. The purpose of the study is to determine the optimum percentage of ethanol and then compare

the performance of the standard car with that of the car using the high concentration ethanol fuel.

- *Ethanol Production Improvement.* Increasing the efficiency and therefore, profitability of ethanol production is key to increasing its economic viability. The Department supports an Agricultural Utilization Research Institute study that is looking at methods for increasing the ethanol yield from corn and also increasing the rate at which corn is converted to ethanol.

- *Wood Waste Use Demonstration.* The Department provides funds to help support two wood waste demonstration projects. One, in Pine County, uses wood waste to heat a greenhouse and also to dry corn in the fall; a second project assists a small business in Burnsville to recycle its own waste wood into heating fuel for the business.

- *Projects to Facilitate Wood Waste Use.* The Department has published a Directory of Biomass Energy Facilities in Minnesota. The Department also has prepared a Wood Waste Brokerage Report, which identifies producers and users of wood waste as well as barriers to the recycling and reuse of wood waste.

- *Biomass Tours.* To spur interest in wood waste as an energy source, the Department conducts tours of wood-burning facilities.