Appendices to Application for Certificates of Need for the Prairie Island Nuclear Generating Plant

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Appendix J: Applicant's Environmental Report for Prairie Island Operating License Renewal d: April 2008 ..... J-1

Appendix A1: CON Content Requirement and Completeness Checklist

Authority	Required Information	Location of Required Content
7849.0120A	Showing that denial would adversely affect adequacy, reliability and efficiency	Section 1.2; 1.11 Section 6.10 & Tbl. 6-8 Section 9 Section 10 Section 11
1	Demand forecast for type of energy supplied by proposed facility is accurate	Section 6 – Tbl. 6-8 Section 9.2 Section 10.2
2	Effects of applicant's conservation program and state and federal conservation programs	Section 1.1, 1.3 & 1.5 Section 4.6 Section 6.3 & Tbl. 6-8 Section 7.1 Section 9.2 Section 11.1
3	Effects of applicant's promotional practices on energy demand	Section 6 – Tbl. 6-8 Section 9.2
4	Ability of current facilities and facilities not requiring certificate of need to meet future demand	Section 1 Section 2 Section 4 Section 5 Section 6 & Tbl. 6-8 Section 9
5	Effect of proposed facility in making efficient use of resources	Section 1.1, 1.3, 1.8 & 1.11 Section 2.5 Section 3.4 Section 4.2, 4.5, 4.6 & 4.7 Section 6 & Tbl. 6-8 Section 7

Authority	Required Information	Location of Required Content
		Section 8.2 Section 9 Section 10.1 Section 11
7849.0120B	A more reasonable and prudent alternative has not been demonstrated	Section 6.10
1	Appropriate size, type and timing compared to reasonable alternatives	Section 1.2; 1.5.3; 1.8 Section 4.2; 4.6 Section 5.6 Section 6.3
2	Cost of facility and of its energy compared to reasonable alternatives	Section 1 Section 3A.6; 3B.6.1 Section 4 Section 5 Section 6.3; 6.6 & 6.7 Section 10 Section 11
3	Effects on natural and socioeconomic environment vs. reasonable alternatives	Section 1.1; 1.11 Section 10
4	Expected reliability of facility compared to reasonable alternatives	Section 6.3; 6.4
7849.0120C	Project benefit society by protecting the natural and socioeconomic environment, including human health, considering:	Section 6 – Tbl. 6-8 Section 10
1	Relationship of facility to overall state energy needs	Section 1 Section 6 & Tbl. 6-8 Section 9 Section 10.7 Section 11 & 11.4

Authority	Required Information	Location of Required Content
2	Effects of facility on natural and socioeconomic environment compared to not building facility	Section 1.8 Section 4.6 Section 6.3.2 & Tbl. 6-8
3	Effects of facility inducing future development	Section 6 – Tbl. 6-8 Section 10
4	Socially beneficial uses of the output of the facility, including to protect or enhance environmental quality	Section 6 – Tbl. 6-8 Section 10.1
7849.0120D	Project will comply with relevant policies and regulations of other state and federal agencies and local governments	Section 1.2 Section 1.11
7849.0200	Application procedures and timing	Section 1 Section 4.2 & 4.3 Section 5.2 Section 7.2 Section 9
7849.0210	Filing fee to accompany application	Section 2.6
7849.0220	Contents of application	Section 1 Table of Contents
7849.0230	Draft environmental report	Section 2.5 Section 8
7849.0240	Need Summary and Additional Considerations	Section 1.2
7849.0240, Subp. 1	Need summary contains major factors that justify need for facility	Section 1.2 Section 2.4.2
7849.0240, Subp. 2A	Additional considerations address socially beneficial uses of facility output, including uses to protect or enhance environmental quality	Section 8 Section 10

Authority	Required Information	Location of Required Content
7849.0240, Subp. 2B	Promotional activities that may have given rise to demand	Section 1.2 Section 9.2
7849.0240 Subp. 2C	Effects of the facility in inducing future development	Section 10
7849.0250	Description of proposed LEGF and alternatives	Section 2.5 Section 3 – Tbl. 3-2 Section 4 Section 6 & Tbl. 6-8
A	Description of the facility, including:	Section 1.2, 1.5 & 1.7 Section 2.4 Section 3 Section 3 – Tbl. 3-2 Section 6 – Tbl. 6-8
1	Nominal generating capability and economies of scale on the facility size and timing	Section 1.1 & 1.3 Section 2.1, 2.5, 2.6 Section 3 – Tbl. 3-2 Section 4.7 Section 6 – Tbl. 6-8
2	Anticipated operating cycle including expected annual capacity factor	Section 3.3 Section 3 – Tbl. 3-2 Section 6 – Tbl. 6-8
3	Type of fuel used, including reason for choice of fuel, availability of fuel and alternative fuels, if any	Section 3 Section 3 – Tbl. 3-2 Section 4 Section 6 & Tbl. 6-8
4	Anticipated heat rate of the facility	Section 3B.2, 3B.6 Section 3 – Tbl. 3-2 Section 4.2 & 4.7 Section 6.4 & Tbl. 6-8

Authority	Required Information	Location of Required Content
5	Anticipated areas where the proposed facility could be located	Section 2.3
B	Discuss alternatives available	Section 4 Section 6
1	Purchased power	Section 1.8 Section 2.3 Section 6.3 Section 10.1
2	Increased efficiency of existing facilities, including transmission lines	Section 1.8 Section 2.5 Section 4.5 Section 6.3 Section 8.2 Section 9.2 Section 10.2 & 10.3 Section 11.1 & 11.3
3	New transmission lines	Section 1.8, 1.9 & 1.11 Section 6.3
4	New generating facilities of a different size or using a different energy source as fuel	Section 1.1 Section 11.1.2; 11.3
5	Any reasonable combinations of the alternatives listed in items 1-4	Section 3 Section 4 Section 10.1 Appendix D
C	For the facility and for each alternative in B that could provide electric power at the asserted level of need, discuss:	
1	Capacity cost in current $/kW	Section 3B.6.1 & Tbl. 3-2 Section 6 – Tbl. 6-8

Authority	Required Information	Location of Required Content
2	Service life	Section 3B.6.1 & Tbl. 3-2 Section 6 – Tbl. 6-8
3	Estimated average annual availability	Section 3B.6.1 & Tbl. 3-2 Section 6 – Tbl. 6-8
4	Fuel costs in current $/kWh	Section 3B.6.1 & Tbl. 3-2 Section 4.2 & 4.9 Section 6.4 & Tbl. 6-8 Section 9 Section 10.2
5	Variable operating and maintenance costs in current $/kWh	Section 3 – Tbl. 3-2 Section 6.4 & Tbl. 6-8
6	Total cost in current $/kWh	Section 3B.6.1 & Tbl. 3-2 Section 3B.6.1 & Tbl. 3-2 Section 4.7 & 4.8 Section 6.4 & Tbl. 6-8 Section 9
7	Estimated rate impact, system wide and in Minnesota, assuming a test year beginning with the proposed in-service date	Section 3.11 & Tbl. 3-2 Section 6.7 & Tbl. 6-8 Appendix B
8	Efficiency, expressed for a generating facility as the estimated heat rate, or for a transmission facility as estimated losses under maximum and average loading conditions	Section 1.2, 1.8 & 1.11 Section 3.11, 3B.2 & Tbl. 3-2 Section 4.2 Section 6.3 & Tbl. 6-8 Section 9 Section 10.1 Section 11.3
9	Major assumptions in providing the information in items 1-8, including projected escalation rates for fuel costs,	Section 3.11 & Tbl. 3-2 Section 6 – Tbl. 6-8

Authority	Required Information	Location of Required Content
	O&M costs, and capacity factors	
D	Map showing the applicant's system	Section 3
E	Such other relevant information about the proposed facility and each alternative as may be relevant to need determination	Section 3 Section 4.6.3 Appendix D
7849.0270-0290	System load, annual consumption forecast, capacity and conservation program information	Section 1.1, 1.3, 1.5, 1.11 Section 3.1; 3B.6.1 Section 4.2, 4.6 & 4.9 Section 6.3, 6.4, 6.7 & 6.8 Section 9 Section 11.1 Appendix B.11 Appendix C
7849.0270	Peak Demand and Annual Consumption Forecast	Section 1.11 Section 4.2 Section 9.2 Appendix B.11
7849.0270 subpt. 1	Pertinent data concerning peak demand and annual electrical consumption	Section 9.2 Appendix B.10
7849.0270 subpt. 2	Provide the following data for each forecast year:	
A	Annual consumption by consumers within the MN service area	Appendix B.11
B	Estimates of number of consumers and their annual consumption for:	Section 9.1 Appendix B.11
(1)	Farm, excluding irrigation and drainage pumping	Appendix B.11
(2)	Irrigation and drainage pumping	Appendix B.11
(3)	Nonfarm residential	Appendix B.11

Authority	Required Information	Location of Required Content
(4)	Commercial	Appendix B.11
(5)	Mining	Appendix B.11
(6)	Industrial	Appendix B.11
(7)	Street and highway lighting	Appendix B.11
(8)	Electrified transportation	Appendix B.11
(9)	Other	Appendix B.11
(10)	Sum of sub items (1)-(9)	Appendix B.11
C	Estimated power demand at annual peak demand, broken down as in B.	Appendix B.12
D	System peak demand by month	Appendix B.11
E	Estimated annual revenue requirement per kW-hr (in current dollars)	Section 4
F	Estimated average system weekday load factor by month	Appendix B.11
subpt. 3	Detail of the forecast methodology employed in subpt. 2, including:	Appendix B
A	Overall methodological framework used	Section 4 Appendix B.1
B	Specific analytical techniques used, their purpose and where used	Appendix B.2
C	Manner in which the specific techniques are related	Appendix B.2 & B.3
D	Where statistical techniques have been used:	Appendix B.2
(1)	Purpose of the technique	Appendix B.2
(2)	Typical computations, specifying variables and data	Appendix B.2
(3)	Results of appropriate statistical tests	Appendix B.2

Authority	Required Information	Location of Required Content
E	Forecast confidence levels or ranges for peak demand and consumption	Appendix B.2
F	A brief analysis of the methodology used, including:	Section 4 Appendix B.2
(1)	Strengths and weaknesses	Appendix B.4
(2)	Suitability to the system	Appendix B.4
(3)	Cost considerations	Appendix B.4
(4)	Data requirements	Appendix B.4
(5)	Past accuracy	Appendix B.4
(6)	Other factors considered significant	Appendix B.4
G	Explanation of discrepancies between current and previous forecasts	Appendix B.9 & B.10
subpt. 4	Discussion of the database used in current forecasting, including:	Appendix B.7
A	Complete list and description of all datasets used in the forecast	Appendix B.5
B	Clear identification of adjustments made to raw data including:	Appendix B.7
(1)	Nature of adjustment	Appendix B.7
(2)	Reason for adjustment	Appendix B.7
(3)	Magnitude of adjustment	Appendix B.7
subpt. 5	Discussion of each assumption made in forecast preparation, including:	Appendix B.5 & B.7
A	Availability of alternate sources of energy	Chapter 9 Appendix D
B	Expected conversion from other fuels to electricity or vice versa	Chapter 9 Appendix D

Authority	Required Information	Location of Required Content
C	Future prices and their projected impact upon system demand	Chapter 9.2 Appendix D
D	Subpt. 2 data that is not available historically or internally generated	Appendix D
E	Impact of energy conservation programs upon electrical demand	Section 9.2.2 Appendix D
F	Any other factor considered in preparing the forecast	Section 4 Section 9.2 Appendix D
subpt. 6	Applicant shall provide:	
A	Description of coordination of load forecasts with other systems	Section 9 Appendix B
B	Description of the manner in which forecasts are coordinated	Section 9 Appendix B
7849.0280	Description of ability of existing system to meet forecast demand	Section 1.5 Section 2.5 Section 9
A	Discussion of power planning programs applied	Section 9.2 Appendix B
B	Seasonal firm purchases and sales for each utility in each forecast year	Appendix B
C	Seasonal participation purchases and sales for each utility in each forecast year	Appendix B
D	For the summer and winter season of each forecast year:	Appendix B
(1)	Seasonal system demand	Appendix B
(2)	Annual system demand	Appendix B

Authority	Required Information	Location of Required Content
(3)	Total seasonal firm purchases	Appendix B
(4)	Total seasonal firm sales	Appendix B
(5)	Seasonal adjusted net demand	Appendix B
(6)	Annual adjusted net demand	Appendix B
(7)	Net generating capacity	Appendix B
(8)	Total participation purchases	Appendix B
(9)	Total participation sales	Appendix B
(10)	Adjusted net capability	Appendix B
(11)	Net reserve capacity obligation	Appendix B
(12)	Total firm capacity obligation	Appendix B
(13)	Surplus or deficit capacity	Appendix B
E	Load generation capacity for purchases, sales, and generation in years subsequent to application (see D 1-13)	Appendix B
F	Load generation capacity for projected purchases, sales and generation in years subsequent to application (see D 1-13)	Appendix B
G	List of proposed additions and retirements in generating capacity for each forecast year subsequent to application	Appendix B.13
H	Graph of monthly adjusted net demand and capability; plot of difference between capability and maintenance outages	Appendix B.13
I	Appropriateness and method of determining system reserve margins	Appendix B.13
7849.0290	Application must include the following regarding conservation programs:	

Authority	Required Information	Location of Required Content
A	Party (ies) responsible for energy conservation and efficiency programs	Appendix C.1
B	List of energy conservation and efficiency goals and objectives	Appendix C.2
C	Description of programs considered, implemented and rejected	Appendix C.3
D	Description of major accomplishments in conservation and efficiency	Appendix C.4
E	Description of future plans with respect to conservation and efficiency	Appendix C.5
F	Quantification of the manner by which these programs impact the forecast	Appendix C.6
7849.0300	Consequences of indefinite delay or 1,2, or 3 year postponement	Section 9.3
7849.0310	Environmental information requested	Section 8
7849.0320	Provide data for each alternative that would involve LEGF construction	Section 8 Section 8 – Tbl. 8-10 & 8-11
7849.0320A	Estimated range of land requirements for the facility and a discussion of assumptions on land requirements, water storage, cooling systems, solid waste storage	Section 3.1 Section 8.2.1 Section 10.3 Appendix D.3
B	Estimated vehicular, rail, barge traffic generated by construction and operation of the facility	Section 8.2 Section 8 – Tbl. 8-10 Appendix D.3
C	For fossil-fueled facilities:	
1	Expected regional fuel sources for the facility	Section 3 Section 8 – Tbl. 8-10 & 8-11 Appendix D.3 & D.4
2	Typical fuel requirement during operation at rated capacity and annual	Section 3

Authority	Required Information	Location of Required Content
	fuel requirement at expected capacity factor	Section 6 - Tbl. 6-1 Section 8 – Tbl. 8-10 & 8-11
3	Expected rate of heat input in Btu per hour at rated capacity	Section 3 Section 8 – Tbl. 8-10 & 8-11 Appendix D.3 & D.4
4	Typical range of heat value of the fuel (in Btu/lb, Btu/gallon or Btu/1000Cf) and typical average heat value	Section 3 Section 8 – Tbl. 8-10 & 8-11 Appendix D.3
5	Typical ranges of sulfur, ash and moisture content of the fuel	Section 3 Section 8 – Tbl. 8-10 & 8-11 Appendix D.3
D	For Fossil fueled facilities:	Not Applicable
1	Estimated range of trace element emissions and maximum emissions of SO2, NOx, and PM in lbs/hour during operation at rated capacity	Not Applicable
2	Estimated range of maximum contributions to 24-hour average ground level concentrations at specified distances from stack of SO2, NOx and PM in micrograms/cubic meter at rated capacity and assuming generalized worst-case meteorological conditions	Not Applicable
E	Water use by the facility for alternate cooling systems, including:	Section 3.11 Section 8.2 Section 8 – Tbl. 8-10 & 8-11 Appendix D.2 – D.4
1	Estimated maximum use, including the groundwater pumping rate in gallons/minute and surface water appropriation in cubic feet/second	Section 3.11 Section 8.2 Section 8 – Tbl. 8-10 & 8-11 Appendix D.2 – D.4

Authority	Required Information	Location of Required Content
2	Estimated ground water appropriation in million gallons/year	Section 3.11 Section 8.2 Section 8 – Tbl. 8-10 & 8-11 Appendix D.2 – D.4
3	Annual consumption in acre-feet	Section 3.11 Section 8.2 Section 8 – Tbl. 8-10 & 8-11 Appendix D.2 – D.4
F	Potential sources and types of discharges to water attributable to operation of the facility	Section 8.2.4 Section 8 – Tbl. 8-10 & 8-11 Appendix D.2 – D.4
G	Radioactive releases, including:	Section 8.2.5 Section 8 – Tbl. 8-10 & 8-11
1	For nuclear facilities, typical levels	Section 8.2 Section 8 – Tbl. 8-10 & 8-11
2	For fossil-fueled facilities, the estimated range of radioactivity released by the facility in curies per year	Section 8.2 Section 8 – Tbl. 8-10 & 8-11
H	Potential types and quantities of solid wastes in tons per year at expected capacity factor	Section 8.2.7 Section 8 – Tbl. 8-10 & 8-11
I	Potential sources and types of audible noise attributable to operation	Section 8.2.8 Section 8 – Tbl. 8-10 & 8-11
J	Estimated work force required for construction and operation	Section 8.2.9 Section 8 – Tbl. 8-10 & 8-11
K	Minimum number and size of transmission facilities required to provide reliable outlet	Section 8.2.10 Section 8 – Tbl. 8-10 & 8-11
7849.0340	Alternative of no facility	Section 1.8 & 1.9 Section 4.6

Authority	Required Information	Location of Required Content
		Section 6.3.2 Section 8 Appendix D
A	Expected operation of existing and committed facilities	Section 1.11 Section 2.4 & 2.5 Section 8
B	Description of the changes in resource requirements and wastes produced	Section 1.5 Section 3.1 Section 5.2 Section 6.13 & 6.14 Section 7.3 Section 8 Section 11.1
C	Description of possible methods of reducing environmental impact	Section 8 Section 11.1
§116C.83, subd. 2	Commission process for future additional authorization. Authorization of any additional dry cask storage other than that provided for in subdivision 1, or expansion or establishment of an independent spent-fuel storage facility at a nuclear generation facility in this state, is subject to approval of a certificate of need by the Public Utilities Commission.	Section 2.5.1
Minn. Stat. §216B.243	Certificate of Need Criteria	Section 1.11 Section 2.5.2 Section 11
Subd. 2	Certificate required for this facility	Section 2.5.2 Section 11
Subd. 3	Showing required for construction. In assessing need, the Commission shall evaluate:	
1	Accuracy of the long-range energy demand forecast on which need is based	Section 9 Appendix B.10

Authority	Required Information	Location of Required Content
2	Effect of existing or possible conservation on long-term demand	Section 1.4 & 1.5 Section 2.44 Section 9.2 Appendix D.3
3	Relationship of proposed facility to overall state energy needs, as described in most recent state energy policy report	Section 11.1 Appendix B.10
4	Promotional activities that may have given rise to the demand for this facility	Section 1.2; 1.4 & 1.7 Section 9.2.2 Section 11.1
5	Benefits of this facility, including uses to protect or enhance environmental quality, increase reliability of energy supply	Section 1.5 Section 4 Section 8 Section 10 Section 11.1
6	Possible alternatives for satisfying demand, including increased efficiency and upgrading existing generation, load-management and distributed generation	Section 9.2 Section 11.1 Appendix D
7	Policies, rules and regulations of other state and federal agencies and local governments	Section 2.4 Section 11
8	Feasible combination of energy conservation improvements, that can replace or compete with the facility	Section 9.2
§216B.243, subd. 3a	To allow opportunity for review by the legislature, a decision by the commission on an application for a certificate of need pursuant to subdivision 2 is stayed until the June 1 following the next regular annual session of the legislature that begins after the date of the commission decision.	Section 2.5.1 Section 4 Section 11.1 Appendix D
§216B.243, subd. 3b	Any certificate of need for additional	Section 2.5.1

Authority	Required Information	Location of Required Content
	storage of spent nuclear fuel for a facility seeking a license extension shall address the impacts of continued operations over the period for which approval is sought.	
Minn. Stat. §216B.243 subd. 3a and §216B.2422, subd. 4	Availability of renewable energy alternatives	Section 2.5.2 Section 11.1
Minn. Stat. §216B.1693	Clean Energy Technology Statute	Section 11.3.1
Minn. Stat. §216B.1694 subd. 2(a) (5)	Innovative Energy Project Statute	Section 11.3 Section 11.1
In the Matter of Northern States Power Company d/b/a Excel Energy's Application for Approval of its 2005-2019 Resource Plan – Order dated7-28-06 Approving Plan Re: Docket No. 04-1752	Carbon risk analysis strategies	Section 1.7 & 1.5 Section 4.2 Section 9 Section 11.3

Appendix A2: CON Content Requirement and Completeness Checklist

Authority	Required Information	Location of Required Content
7855.0120 (A)	A Certificate of Need must be granted to an applicant if it is determined that: The probable direct or indirect result of denial would be an adverse effect upon the future adequacy, reliability, safety, or efficiency of energy supply to the applicant, to the applicant's customers, or to the people of Minnesota and neighboring states, considering:	Section 1.2 Section 1.10 Section 6.10 Section 9 Section 10 Section 11
7855.0120 (A) (1)	The accuracy of the applicant's forecast of demand for the energy or services that would be supplied by the proposed facility;	Section 1.11
7855.0120 (A) (2)	The effects of existing or expected conservation programs of the applicant, the state government, or the federal government;	Section 1.11
7855.0120 (A) (3)	The effects of promotional practices in creating a need for the proposed facility, particularly promotional practices that have occurred since 1974;	Section 1.11
7855.0120 (A) (4)	The ability of current facilities and planned facilities not requiring certificates of need to meet the future demand; and	Section 1.11
7855.0120 (A) (5)	The effect of the proposed facility, or a suitable modification thereof, in making efficient use of resources;	Section 1.11
7855.0120 (B)	A Certificate of Need must be granted to an applicant upon determining that four principal criteria are met: a more reasonable and prudent alternative to the proposed facility has not been demonstrated by a preponderance of the evidence on the record by parties or persons other than the applicant.	Section 1.11 Section 4.1
7855.0120 (B) (1)	The appropriateness of the size, the type, and the timing of the proposed facility compared to those of reasonable alternatives;	Section 1.11
7855.0120 (B) (2)	The cost of the proposed facility and the	Section 1.11

Authority	Required Information	Location of Required Content
	cost of energy to be supplied by the proposed facility compared to the cost of reasonable alternatives and the cost of energy that would be supplied by reasonable alternative;	
7855.0120 (B) (3)	The effect of the proposed facility upon the natural and socioeconomic environments compared to the effects of reasonable alternatives; and	Section 1.11
7855.0120 (B) (4)	The expected reliability of the proposed facility compared to the expected reliability of reasonable alternatives;	Section 1.11
7855.0120 (C)	It has been demonstrated by a preponderance of the evidence on the record that the consequences of granting the certificate of need for the proposed facility, or a suitable modification thereof, are more favorable to society than the consequences of denying the certificate, considering:	Section 1.11 Section 10
7855.0120 (C) (1)	The relationship of the proposed facility, or a suitable modification thereof, to overall state energy needs;	Section 6.4 Section 9.2 Section 10
7855.0120 (C) (2)	The effects of the proposed facility, or a suitable modification thereof, upon the natural and socioeconomic environments compared to the effects of not building the facility.	Section 1 Section 4.6 Section 6.3 Section 10
7855.0120 (C) (3)	The effects of the proposed facility, or a suitable modification thereof, in inducing future development; and	Section 10.7
7855.0120 (C) (4)	The socially beneficial uses of the output of the proposed facility, or a suitable modification thereof, including its uses to protect or enhance environmental quality; and	Section 10
7855.0120 (D)	That it has not been demonstrated on the record that the design, construction, operation, or retirement of the proposed facility will fail to comply with those relevant policies, rules, and regulations of other state and federal agencies and local	Section 11

Authority	Required Information	Location of Required Content
	governments.	
7855.0230 (A)	Each application shall include the following general information: The applicant's complete name and address, telephone number, and standard industrial classification codes.	Section 1.1 Section 9
7855.0230 (B)	Each application shall include the following general information: The complete name, title, address, and telephone number of the official or agent to be contacted concerning the applicant's filing.	Section 2.2
7855.0230 (C)	Each application shall include the following general information: A brief description of the nature of the applicant's business and of the products that are manufactured, produced, or processed, or of the services rendered.	Section 2.3
7855.0230 (D)	Each application shall include the following general information: A brief description of the proposed facility and its planned use.	Section 2.4
7855.0230 (E)	Each application shall include the following general information: The total fee for the application as prescribed by part 7855.0210 and the amount of the fee submitted with the application.	Section 2.6
7855.0230 (F)	Each application shall include the following general information: The signatures and titles of the applicant's officers or executives authorized to sign the application, and the signature of the preparer of the application if prepared by an outside agent.	Section 2.7
7855.0240 (A)	Each application shall contain a schedule listing all known federal, state, and local agencies or authorities with which the applicant must file for the proposed facility. The following information shall be included on the schedule: The names of all known federal, state, or local authorities with which the applicant	Section 1.3, 1.5 & 1.8 Section 2.5 Section 9

Authority	Required Information	Location of Required Content
	must file.	
7855.0240 (B)	Each application shall contain a schedule listing all known federal, state, and local agencies or authorities with which the applicant must file for the proposed facility. The following information shall be included on the schedule: The title of each required permit or certificate issued by the authorities named in response to item A and needed by the applicant.	Section 1.2 & 1.11 Section 2.1, & 2.7 Section 4.1, 4.2 & 4.6 Section 5.1 & 5.6 Section 6.1 & 6.3 Section 9 Section 10 Section 11
7855.0240 (C)	Each application shall contain a schedule listing all known federal, state, and local agencies or authorities with which the applicant must file for the proposed facility. The following information shall be included on the schedule: For each permit or certificate listed in response to item B, the date an application was filed or the projected date of future application.	Section 2.5 Section 3A.6 Section 4.2.1 & 4.6.3 Section 5.1, 5.3.1 & 5.4 Section 11.3
7855.0240 (D)	Each application shall contain a schedule listing all known federal, state, and local agencies or authorities with which the applicant must file for the proposed facility. The following information shall be included on the schedule: For each permit or certificate listed in response to item B, the actual date a decision was made on the application, or the anticipated decision date.	Section 2.5 Section 3A.6 Section 4.2.1 & 4.6.3 Section 5.1, 5.3.1 & 5.4 Section 11.3
7855.0240 (E)	Each application shall contain a schedule listing all known federal, state, and local agencies or authorities with which the applicant must file for the proposed facility. The following information shall be included on the schedule: For each permit or certificate listed in response to item B for which an application was filed, the disposition or status of the permit or certificate.	Section 1.2 & 1.11 Section 2.5 Section 3A.6 Section 4.2.1 & 4.6.3 Section 5.1, 5.3.1 & 5.4 Section 6.1 & 6.3 Section 11.3

Authority	Required Information	Location of Required Content
7855.0250	Each application shall contain a summary of the major factors that justify the need for the proposed facility. Except upon prior approval of the commission, this summary shall not exceed 15 pages, including text, tables, graphs, and figures.	Section 1.2 & 1.5 Section 2.4.2 & 2.5 Section 9 & 9.2 Appendix B
7855.0260 (A)	Each application shall contain an explanation of the relationship of the proposed facility to each of the following socioeconomic considerations: Socially beneficial uses of the output of the facility, including its uses to protect or enhance environmental quality.	Section 1.5 Section 4 Section 8 Section 10 Section 11.1
7855.0260 (B)	Each application shall contain an explanation of the relationship of the proposed facility to each of the following socioeconomic considerations: Promotional activities that may have given rise to the demand for the facility.	Section 1.2, 1.4, 1.5 & 1.7 Section 2.5 Section 9 & 9.2 Section 11.1 Appendix B
7855.0260 (C)	Each application shall contain an explanation of the relationship of the proposed facility to each of the following socioeconomic considerations: The effects of the facility in inducing future development.	Section 1.5 Section 2.5 Section 9 & 9.2 Section 10 Appendix B
7855.0270 (A)	Each application shall include the following information: The name of the committee, department, or individual responsible for the applicant's energy conservation and efficiency programs.	Section 1.11 Section 4.2 Section 9.2 Appendix B.11 Appendix C.1
7855.0270 (B)	Each application shall include the following information: A list of the applicant's energy conservation and efficiency goals and objectives.	Section 1.11 Section 4.2 Section 9.2 Appendix B.11 Appendix C.1

Authority	Required Information	Location of Required Content
7855.0270 (C)	Each application shall include the following information: A description of the specific energy conservation and efficiency programs the applicant has considered, a list of those that have been implemented, and the reasons why the other programs have not been implemented.	Section 1.11 Section 4.2 Section 9.2 Appendix B.11 Appendix C.1
7855.0270 (D)	Each application shall include the following information: A description of the major accomplishments that have been made with respect to energy conservation and efficiency.	Section 1.1, 1.3, 1.5 & 1.11 Section 4.2 & 4.6 Section 6.3 Section 7.1 Section 9.2 Section 11.1 Appendix B.11 Appendix C.4
7855.0270 (E)	Each application shall include the following information: A description of the applicant's future plans through the forecast years with respect to energy conservation and efficiency.	Section 1.11 Section 4.2 Section 9.2 Appendix B.11 Appendix C.5
7855.0270 (F)	Each application shall include the following information: A quantification of the manner by which these programs affect or help determine the applicant's forecast of demand, a list of the total costs by program, and a discussion of the expected effects in reducing the need for new large energy facilities.	Section 1.11 Section 3B.6.1 Section 4.2 Section 9.2 Appendix B.11 Appendix C.6
7855.0600 (A) (1)	Each application for a nuclear waste storage or disposal facility shall contain the following information: A physical description of the facility, including: Its location, to the fullest extent known.	Section 1.2, 1.5 & 1.7 Section 2.3 & 2.4 Section 3
7855.0600 (A) (2)	Each application for a nuclear waste storage or disposal facility shall contain the following information: A physical	Section 1.1 & 1.3 Section 2.1, 2.5, 2.6

Authority	Required Information	Location of Required Content
	description of the facility, including: The required land area, the height of the tallest structures, and if applicable, the depth and size of any underground caverns.	Section 3.1 Section 4.7 Section 8.2.1 Section 10.3 Appendix D.3
7855.0600 (A) (3)	Each application for a nuclear waste storage or disposal facility shall contain the following information: A physical description of the facility, including: Its design capacity in cubic meters.	Section 3.3
7855.0600 (A) (4)	Each application for a nuclear waste storage or disposal facility shall contain the following information: A physical description of the facility, including: A schematic drawing showing major components of the facility.	Section 3 Section 5
7855.0600 (B) (1)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding design and construction of the facility, including: If known, the complete name and business address of the engineer and firm that would be responsible for the design of the facility.	Section 1.5 & 1.11 Section 2.5 Section 3 Section 4.4.1 Section 5 Section 7.2 Section 8.2 Section 11
7855.0600 (B) (2)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding design and construction of the facility, including: If known, the complete name and business address of the company which would construct the facility.	Section 1.5 & 1.11 Section 2.5 Section 3.3, 3A.2, 3A.6 & 3B Section 4.4.1 Section 5.2.3, 5.2.4, 5.3, 5.4 Section 7.2 Section 8.2 Section 11
7855.0600 (B) (3)	Each application for a nuclear waste storage or disposal facility shall contain	Section 3B.6

Authority	Required Information	Location of Required Content
	the following information: Data regarding design and construction of the facility, including: The proposed date for commencing construction and the proposed in-service date.	Section 5.4
7855.0600 (B) (4)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding design and construction of the facility, including: A description of the construction techniques.	Section 5.2 Section 6.3 Section 7 Section 8.2 & 8.3 Section 9.3 Section 10.3 & 10.6 Section 11
7855.0600 (B) (5)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding design and construction of the facility, including: The estimated installed cost of the facility in current dollars	Section 5.2
7855.0600 (B) (6)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding design and construction of the facility, including: The estimated economic life of the facility	Section 3B.6.2
7855.0600 (C) (1)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding operation and retirement of the facility, including: A narrative description of the steps of the storage or disposal process, starting at the point the nuclear wastes are produced.	Section 1.5 & 1.11 Section 2.4 & 2.5 Section 3.1 Section 5.2 Section 6.13 & 6.14 Section 7.3 Section 8 Section 11.1
7855.0600 (C) (2)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding operation and retirement of the facility,	Section 1.5 & 1.11 Section 2.4 & 2.5 Section 3.1

Authority	Required Information	Location of Required Content
	including: The sources, types, and amounts of nuclear waste products that would be stored, the methods of transporting these materials to the facility, and the level of radioactivity of each in curies per year.	Section 5.2 Section 6.13 & 6.14 Section 7.3 Section 8 Section 11.1 Appendix B.13
7855.0600 (C) (3)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding operation and retirement of the facility, including: If the facility is only for temporary storage, the length of time material would be stored there and the method of transporting the material to its disposal site	Section 1.11 Section 2.4 & 2.5 Section 8
7855.0600 (C) (4)	Each application for a nuclear waste storage or disposal facility shall contain the following information: Data regarding operation and retirement of the facility, including: The expected maintenance requirements of the facility, if any.	Section 1.4 Section 3.3 Section 4.2, 4.3, 4.6, 4.7 & 4.9 Section 6.4 Section 10.4 & 10.5
7855.0610 (A)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The description of each alternative shall include the following information, if applicable: The location of the facility, to the fullest extent known	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (B)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the	Section 1 Section 2.4 & 2.5

Authority	Required Information	Location of Required Content
	applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The required land area, the height of the tallest structures, and if applicable, the depth and size of any underground caverns.	Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (C)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. Its design capacity in the appropriate units of measure.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (D)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. A schematic drawing showing major components of the facility.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3

Authority	Required Information	Location of Required Content
7855.0610 (E)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The probable date for commencing construction and the probable in-service date.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (F)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The estimated installed cost of the alternative in current dollars.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (G)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The sources, types, and amounts of nuclear waste products that would be involved in the alternative, the methods of transporting these materials, and the level of radioactivity of each in curies per year.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1

Authority	Required Information	Location of Required Content
		Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (H)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The estimated maintenance requirements of the alternative.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (I)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The estimated economic life of the facilities involved in the alternative.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6 Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0610 (J)	Each application for a nuclear waste storage or disposal facility shall contain a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing, or design. The reasons why the alternative was rejected.	Section 1 Section 2.4 & 2.5 Section 3.1, 3A.6; 3B.6.1 Section 4, 4.2; 4.6 Section 5, 5.2 & 5.6

Authority	Required Information	Location of Required Content
		Section 6 Section 7.3 Section 8 & 8.2.1 Section 10 & 10.3 Section 11 & 11.1 Appendix D.3
7855.0620 (A)	Each applicant for a nuclear waste storage or disposal facility shall provide five years of historical data, as well as a forecast of demand through the forecast years. The following information shall be included: For each material that would be stored in the proposed facility, the amount (in cubic meters) produced nationally and within Minnesota during each of the last five calendar years preceding the year of application.	Section 4 Appendix B
7855.0620 (B)	Each applicant for a nuclear waste storage or disposal facility shall provide five years of historical data, as well as a forecast of demand through the forecast years. The following information shall be included: For each of the last five calendar years preceding the year of application, the year-end capacity (in cubic meters) within Minnesota and within the United States to store the materials listed in response to item A.	Section 4 Appendix B
7855.0620 (C)	Each applicant for a nuclear waste storage or disposal facility shall provide five years of historical data, as well as a forecast of demand through the forecast years. The following information shall be included: An estimate of the amount (in cubic meters) of each material listed in response to item A expected to be produced nationally and within Minnesota during the first six forecast years, the 11th forecast year (the tenth year after the year of application), and the 16th forecast year.	Section 4 Section 9.2 Section 10.2 Appendix B

Authority	Required Information	Location of Required Content
7855.0620 (D)	Each applicant for a nuclear waste storage or disposal facility shall provide five years of historical data, as well as a forecast of demand through the forecast years. The following information shall be included: A list of known facilities to be added in the United States during the forecast years, including locations, design capacities (in cubic meters), and in-service dates, for storing the same types of materials that would be stored in the proposed facility.	Section 4 Appendix B
7855.0620 (E)	Each applicant for a nuclear waste storage or disposal facility shall provide five years of historical data, as well as a forecast of demand through the forecast years. The following information shall be included: The expected years during which the material stored in the proposed facility would reach ten percent, 25 percent, 50 percent, and 100 percent of the capacity of the facility.	Section 4 Appendix B
7855.0620 (F)	Each applicant for a nuclear waste storage or disposal facility shall provide five years of historical data, as well as a forecast of demand through the forecast years. The following information shall be included: A discussion of the methodology, statistical techniques, and data bases used in providing the forecast data required by items C and E.	Section 4 Appendix B
7855.0620 (G)	Each applicant for a nuclear waste storage or disposal facility shall provide five years of historical data, as well as a forecast of demand through the forecast years. The following information shall be included: Any major assumptions made in supplying the information required by items A to E, and a discussion of the sensitivity of the information to changes in the assumptions.	Appendix B.2
7855.0630	Each applicant shall provide	Section 1.1; 1.11

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	environmental data for the proposed facility and for each alternative facility described in response to part 7855.0610. The information in parts 7855.0640 to 7855.0670 relating to construction and operation of each of these facilities shall be provided to the extent that such information is reasonably available to the applicant and applicable to the particular alternative.	Section 8 Section 10
7855.0640 (A)	The applicant shall provide a description of each alternative site, including: The nature of the terrain at the site.	Section 7.2.1
7855.0640 (B)	The applicant shall provide a description of each alternative site, including: The general soil types at the site.	Section 7.2.2 Section 7 – Tbl. 7-1
7855.0640 (C)	The applicant shall provide a description of each alternative site, including: The types and depths of bedrock underlying the site.	Section 7.2.3 & 7.2.7
7855.0640 (D)	The applicant shall provide a description of each alternative site, including: The depth to groundwater at the site.	Section 7.2.4 Section 8.2.3
7855.0640 (E)	The applicant shall provide a description of each alternative site, including: The types of vegetation (forest, brush, marsh, pasture, and cropland) on the site, and the approximate percentage of each.	Section 7.2.6
7855.0640 (F)	The applicant shall provide a description of each alternative site, including: The predominant types of land use (such as residential, forest, agricultural, commercial, and industrial) within five miles of the site, and the approximate percentage of each.	Section 7.2.6 Section 9.1 Appendix B.11
7855.0640 (G)	The applicant shall provide a description of each alternative site, including: Lakes, streams, wetlands, or drainage ditches within five miles of the site, and any other lakes, streams, wetlands, drainage ditches, wells, or storm drains into which liquid contaminants from the site could flow.	Section 7.2.7 & 7.2.9 Section 7 – Tbl. 7-3

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7855.0640 (H)	The applicant shall provide a description of each alternative site, including: Trunk highways, airports, and air traffic corridors within five miles of the site.	Section 3.1 Section 7.2.8 Section 8.2.1 Section 10.3 Appendix D.3
7855.0640 (I)	The applicant shall provide a description of each alternative site, including: National natural landmarks, national wilderness areas, national wildlife refuges, national wild and scenic rivers, national parks, national forests, national trails, and national waterfowl production areas within five miles of the site, as mapped on the inventory of significant resources by the State Planning Agency.	Section 7.2.9
7855.0640 (J)	The applicant shall provide a description of each alternative site, including: State critical areas, state wildlife management areas, state scientific and natural areas, state wild, scenic, and recreational rivers, state parks, state scenic wayside parks, state recreational areas, state forests, state trails, state canoe and boating rivers, state zoo, designated trout streams, and designated trout lakes within five miles of the site, as mapped on the inventory of significant resources by the State Planning Agency.	Section 7.2.9
7855.0640 (K)	The applicant shall provide a description of each alternative site, including: National historic sites and landmarks, national monuments, national register historic districts, registered state historic or archaeological sites, state historical districts, sites listed on the National Register of Historic Places, and any other cultural resources within five miles of the site, as indicated by the Minnesota Historical Society.	Section 3 Section 7.2.9
7855.0640 (L)	The applicant shall provide a description of each alternative site, including: Areas within five miles of the site designated by	Section 3 Section 7.2.11

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	regional or local authorities as having recreational, cultural, historical, or scientific significance, as indicated by local units of government.	
7855.0640 (M)	The applicant shall provide a description of each alternative site, including: The estimated total population within 50 miles of the site, and a map showing the distribution of the population within 50 miles of the site.	Section 3 Section 7.2.12
7855.0650 (A)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: The types and estimated amounts of solid, liquid, and gaseous radioactive wastes that would be produced by the facility, and the level of radioactivity of each in curies per year.	Section 1.5 Section 3.1 Section 5.2 Section 6.13 & 6.14 Section 7.3 Section 8, 8.2 Section 11.1
7855.0650 (B)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: An analysis of human exposure to ionizing radiation attributable to operation of the facility, taking account of the pathways of radioactive releases to humans.	Section 1.5 Section 3.1 Section 5.2 Section 6.13 & 6.14 Section 7.3.2 Section 8, 8.2 Section 11.1
7855.0650 (C)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: The types and estimated amounts of nonradioactive solid and liquid wastes that would be produced.	Section 1.5 Section 3.1 Section 5.2 Section 6.13 & 6.14 Section 7.3.2 Section 8, 8.2 Section 11.1
7855.0650 (D)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility,	Section 1.5 Section 3.1

Authority	Required Information	Location of Required Content
	including: The types and estimated amounts of nonradioactive gaseous and particulate emissions into the air that would occur during full operation from each emission source, and the location and nature of the release point.	Section 5.2 Section 6.13 & 6.14 Section 7.3.3 & 7.3.4 Section 8 Section 11.1
7855.0650 (E)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: Locations that may be sources of fugitive dust and the nature of each source.	Section 1.5 Section 3.1 Section 5.2 Section 6.13 & 6.14 Section 7.3.5 Section 8 Section 11.1
7855.0650 (F)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: The nature and estimated amount of nonradioactive discharges to water, and the locations, routes, and final receiving waters for any discharge points.	Section 1.5 Section 3.1 & 3.11 Section 5.2 Section 6.13 & 6.14 Section 7.3.6 Section 8, 8.2 Appendix D.2 – D.4
7855.0650 (G)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: Any area from which runoff may occur, potential sources of contamination in the area, and receiving waters for any runoff.	Section 1.5 Section 3.1 & 3.11 Section 5.2 Section 6.13 & 6.14 Section 7.3.7 Section 8, 8.2 Appendix D.2 – D.4
7855.0650 (H)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: The sources and estimated amounts of heat rejected by the facility.	Section 1.5 Section 3.1, 3B.2 & 3B.6 Section 4.2 & 4.7 Section 5.2

Authority	Required Information	Location of Required Content
		Section 6.4, 6.13 & 6.14 Section 7.3.8 Section 8 Section 11.1
7855.0650 (I)	The applicant shall provide data on wastes and emissions associated with construction or operation of the facility, including: The maximum noise levels (in decibels, A scale) expected at the property boundary and the expected maximum increase over ambient noise levels.	Section 1.5 Section 3.1 Section 5.2 Section 6.13 & 6.14 Section 7.3.9 Section 8, 8.2.8 Section 11.1
7855.0660 (A)	The applicant shall provide data regarding pollution control and safeguards equipment, including: The provisions that would be made for management of radioactive materials.	Section 7.4.1
7855.0660 (B)	The applicant shall provide data regarding pollution control and safeguards equipment, including: A description of contingency plans to reduce the effects of an accidental release of radioactive materials	Section 7.4.2 Section 8 Section 11.1
7855.0660 (C)	The applicant shall provide data regarding pollution control and safeguards equipment, including: The methods that would be used to recycle or dispose of solid or liquid wastes	Section 7.4.3
7855.0660 (D)	The applicant shall provide data regarding pollution control and safeguards equipment, including: The types of emission control devices and dust control measures that would be used	Section 7.4.4
7855.0660 (E)	The applicant shall provide data regarding pollution control and safeguards equipment, including: The types of water pollution control equipment and runoff control measures that would be used	Section 7.4.5

Authority	Required Information	Location of Required Content
7855.0660 (F)	The applicant shall provide data regarding pollution control and safeguards equipment, including: The measures that would be taken to prevent spills or leaks of pollutants, or to minimize the effects of spills or leaks on the environment	Section 7.4.6
7855.0660 (G)	The applicant shall provide data regarding pollution control and safeguards equipment, including: The methods that would be used to reduce the effects of heat rejected by the facility	Section 7.4.7 Section 8 Section 11.1
7855.0660 (H)	The applicant shall provide data regarding pollution control and safeguards equipment, including: Any other equipment or measures, including noise control or erosion control, that would be used to reduce the effects of the facility on the environment	Section 7.4.8 Section 8 Section 11.1
7855.0660 (I)	The applicant shall provide data regarding pollution control and safeguards equipment, including: The types of environmental monitoring, if any, that are planned for the facility and a description of any relevant environmental monitoring data already collected.	Section 7.4.9 Section 8
7855.0670 (A)	The applicant shall provide estimates of induced developments, including: The types and amounts of vehicular traffic that would be generated by the facility due to construction activity and, later, to operational needs.	Section 3 Section 7.5.1 Section 8.2 Section 10.3 Appendix D.3
7855.0670 (B)	The applicant shall provide estimates of induced developments, including: The work forces required for construction and for operation of the facility.	Section 7.5.2
7855.0670 (C)	The applicant shall provide estimates of induced developments, including: The extent to which the facility would create or add to the need for expanded utility or public services, including high voltage transmission lines, access roads, and the	Section 1.8, 1.9 & 1.11 Section 2.5 Section 4.5 Section 6.3

Authority	Required Information	Location of Required Content
	like.	Section 7.5.3 Section 8.2 Section 9.2 Section 10.2 & 10.3 Section 11.1 & 11.3
7855.0670 (D)	The applicant shall provide estimates of induced developments, including: The amount of water that would be appropriated and the amount that would be consumed by the facility, the expected source of the water, and the uses for the water.	Section 7.5.4 Section 8.2.4 Appendix D.2 – D.4
7855.0670 (E)	The applicant shall provide estimates of induced developments, including: The amount of agricultural land, including pasture land, that would be removed from agricultural use if the facility were constructed, and known circumstances associated with the facility that could lead to reduced productivity of surrounding agricultural land.	Section 7.5.5
7855.0670 (F)	The applicant shall provide estimates of induced developments, including: The number of people that would have to relocate if the facility were constructed.	Section 1.11 Section 5.2 Section 7.5.6 Section 8.2 Section 10 Section 11.1 & 11.3

Appendix B: System Demand and Capability Data

B.1 Overall Methodological Framework

Xcel Energy prepares its forecast by major customer class and jurisdiction, using a variety of statistical and econometric techniques. The NSP system serves five jurisdictions. Minnesota, North Dakota, and South Dakota are served by Northern States Power Company, a Minnesota corporation (NSP), Wisconsin and Michigan are served by Northern States Power Company, a Wisconsin corporation (NSPW). The NSP and NSPW Systems operate as an integrated system. The forecast is referred to as the 2007 Resource Plan Forecast (October 2007). The overall methodological framework is "model oriented."

B.2 Specific Analytical Techniques

1. Econometric Analysis. Xcel Energy uses econometric analysis to develop jurisdictional MWh sales forecasts at the customer meter for the following sectors:

   a. Residential without Space Heating;

   b. Residential with Space Heating;

   c. Small Commercial and Industrial;

   d. Large Commercial and Industrial.

   Xcel Energy also uses econometric analysis to develop the total system MW demand forecast.

2. Trend analysis is used for the "Other" sectors, which includes Public Street and Highway Lighting, Other Sales to Public Authorities, Interdepartmental sales, and Municipals (firm Wholesale).

3. Loss Factor Methodology. Loss factors by legal entity are used to convert the sales forecasts into system or native energy requirements (at the generator).

4. Judgment. Judgment is inherent to the development of any forecast. Whenever possible, Xcel Energy uses quantitative models to structure its judgment in the forecasting process.

The Energy Forecast (Native Energy Requirements), was developed by summing the jurisdictional class sales forecasts and by adding the loss factor for each legal entity to the sum of the jurisdictional sales forecasts. The system loss factors for each legal entity were developed based on average historical losses. After the Native Energy Requirements are calculated, the 12-month sum of the native energy requirements, along with peak producing weather and binary variables, are then used as independent variables within an econometric model to forecast MW peak demand for the NSP System.

B.3 Models Used

1. Residential Econometric Models. Sales to the residential sectors represented 27.0 percent of total NSP System electric sales in 2006. Residential sales are divided into with space heating and without space heating customer classes for each jurisdiction. Ordinary Least Squares (OLS) regression models using historical data are developed for each residential sector. A variety of independent variables are used in the models, including:
   - Number of customers;
   - Actual heating and temperature humidity index (THI) degree days;
   - Number of monthly billing days.
2. Small Commercial and Industrial Econometric Models. The small commercial and industrial sector represented 41.6 percent of NSP System electric sales in 2006. The models are OLS regressions using historical data. The models include a combination of variables, including:
   - Number of small commercial and industrial customers;
   - Gross Metro Product for respective jurisdiction;
   - Actual heating and temperature humidity index (THI) degree days.
3. Large Commercial and Industrial Econometric Models. Sales to the large commercial and industrial sector represented 27.8 percent of NSP System electric sales in 2006. The models are OLS regressions using historical data and a combination of variables, including:
   - Employment for respective jurisdiction;
   - Number of monthly billing days;
   - Indicator variables such as C&I reclassification.

4. Others. Sales to the "Others" sector represented 0.7 percent of NSP System electric sales in 2006. The Other sector includes Public Street and Highway Lighting (PSHL), Sales to Public Authorities (OSPA) and Interdepartmental (IDS) sales. Because this class represents a very small portion of the total sales, trend analysis is used and very little growth is forecast.

5. Municipals. Sales to the Municipal utility sector represented 2.9 percent of NSP System electric sales in 2006. The municipal class is forecast using separate trend analysis at the individual customer level for NSP and NSPW. The forecast of these municipal customers only includes firm wholesale customer usage.

6. Peak Demand Model.[1] An econometric model is developed to forecast base peak demand for the entire planning period. The model includes a combination of variables, including:
   - Weather normalized native energy requirements;
   - Peak producing weather by month;
   - Binary variables.

B.4 Methodology Strengths and Weaknesses

The strength of the process we use for this forecast is the richness of the information obtained during the analysis. Our econometric forecasting models are based on sound economic and statistical theory. Historical modeling and forecast drivers are based on economic and demographic variables that are easily measured and analyzed. The use of models by class and jurisdiction gives greater insight into how the NSP System is growing, thereby providing better information for decisions to be made in the areas of generation, transmission, marketing, conservation, and load management.

With respect to accuracy, forecasts of this duration are inherently uncertain. Planners and decision makers must be aware of the inherent risk that accompanies long-term forecasts. They must also, however, develop plans that are robust over a wide range of future outcomes.

[1] The appropriate statistical tests related to the development of the peak demand and energy forecasts are too voluminous to include with this filing. Such information will be provided upon request.

B.5 Forecast Database

B.5.1 Data Definitions

The following is a list of definitions of the variables considered in Xcel Energy's econometric models.

B.5.1.1 Jurisdiction Abbreviations

M or MN	State of Minnesota
N or ND	State of North Dakota
S or SD	State of South Dakota
W or WI	State of Wisconsin
Mi or MI	State of Michigan

B.5.1.2 Monthly MWh Sales Series

SLS(Juris)RX	Residential without space heating for given jurisdiction
SLS(Juris)RH	Residential with space heating for given jurisdiction
SLS(Juris)SCI	Small commercial and industrial for given jurisdiction
SLS(Juris)LCI	Large commercial and industrial for given jurisdiction

B.5.1.3 Monthly Customer Series

NRX(Juris)	Residential without space heating for given jurisdiction
NRH(Juris)	Residential with space heating for given jurisdiction
NSCI(Juris)	Small commercial and industrial for given jurisdiction
NLCI(Juris)	Large commercial and industrial for given jurisdiction

B.5.1.4 Monthly Economic and Demographic Series

(Juris)HH	Number of Households in given jurisdiction
GMP(MSA)	Gross Metro Product for given metropolitan statistical area
EEA_(Juris)	Total non-farm employment in given jurisdiction
EM_(Juris)	Total manufacturing employment in given jurisdiction
EnonM_(Juris)	Total non-manufacturing employment in given jurisdiction
YP96(Juris)	Personal income in given jurisdiction

B.5.1.5 Monthly Data Variables used in Demand Model

THI12(Month)Cust	Temperature Humidity Index @12:00 noon multiplied by total retail customers
THI15(Month)Cust	Temperature Humidity Index @ 3:00 p.m. multiplied by total retail customers
HDDWtr	Normal Heating Degree Days on the day of the Peak multiplied by a binary variable for December, January

	and February
WNEnergy12MoSum	12 month rolling sum of the weather normalized net energy requirements

B.5.1.6 Monthly Weather Variables

R(Juris)H65(Month)	HDD base 65 for given jurisdiction and month
R(Juris)T65(Month)	THI DD base 65 for given jurisdiction and month

B.5.1.7 Monthly Binary Variables

Jan	Binary variable for the month of January
Feb	Binary variable for the month of February
Mar	Binary variable for the month of March
Apr	Binary variable for the month of April
May	Binary variable for the month of May
Jun	Binary variable for the month of June
Jul	Binary variable for the month of July
Aug	Binary variable for the month of August
Sep	Binary variable for the month of September
Oct	Binary variable for the month of October
Nov	Binary variable for the month of November
Dec	Binary variable for the month of December

We use both internal and external data sources to create our MWh sales and MW peak demand forecast.

Historical MWh sales are taken from our internal company records, which are fed by our billing system. Historical coincident net peak demand data is also obtained through company records. The load management estimate, as determined through load research, is added to the net peak demand to derive the base peak demand.

Weather data (dry bulb temperature and dew points) are collected from a respected local meteorologist (Mr. Frank Watson) for the Minneapolis/St. Paul, Fargo, Sioux Falls, and Eau Claire areas. The heating degree-days and THI degree-days are calculated internally based on this weather data.

Economic and demographic data is obtained from the Bureau of Labor Statistics, U.S. Department of Commerce, and the Bureau of Economic Analysis. Typically they are downloaded from Global Insight, Inc. data banks, and reflect the most recent values of the series at time of modeling.

B.6 Overview of Probability Distributions

We use a straightforward extension of the peak demand econometric model to assess risk around the expected value of the peak demand by conducting a Monte Carlo simulation on the main drivers of the peak model (weather and native energy requirements). For the Monte Carlo energy probability distribution model, the main drivers are weather and Minnesota Gross State Product (MN GSP).

The Monte Carlo stochastic simulation of peak demand (MW) or (energy (MWh)) involves taking 10,000 random draws from the weather probability distributions as well as 10,000 draws from the 12-month sum of energy probability distribution (or MN GSP probability distribution), which, in turn, produces 10,000 forecasts of peak demand (or energy), and thus generates a probability distribution around the mean peak demand (or mean energy).

For example, if the econometric model forecasts that the mean peak demand for 2022 is 11,379 MW, then using the same econometric model, the Monte Carlo simulation method forecasts that there is a 90 percent probability that the 2022 peak demand will be less than 12,105 MW, or alternatively, a 10 percent chance that the peak will be less than 10,660 MW.

In summary, the Monte Carlo stochastic simulation method adequately captures the effect of extreme weather on monthly peak demand and monthly energy usage, while preserving the expected value or mean forecast of peak demand and energy.

B.7 Data Adjustments and Assumptions

1. Weather Adjustments. We adjusted the monthly weather data to reflect billing schedules. Therefore, the monthly weather data corresponds exactly with the billing month schedule.
2. Economic Adjustments. All price data and related economic series are deflated to 2000 constant dollars.

B.7.1 Assumptions and Special Information

The data used in our forecasting process has already been discussed in a general way. Descriptions and citations of sources for the data sets have been mentioned within this documentation under different sections.

We believe that our process is a reasonable and workable one to use as a guide for our future energy and load requirements. The underlying assumptions used to prepare our median forecast are as follows:

1. Demographic Assumption. Population or household projections are essential in the development of the long-range forecast. The forecasts of customers are derived from population and household projections provided by Global Insight, Inc., and reviewed by Xcel Energy staff. Xcel Energy customer growth mirrors demographic growth over the forecast period.

2. Weather Assumption. We assume "normal" weather in the forecast horizon. Normal weather is defined as the average weather pattern over the 20-year period from 1987-2006. The variability of weather is an important source of uncertainty. Our energy forecasts are based on the assumption that the normal weather conditions will prevail in the forecast horizon. Weather-related demand uncertainties are not treated explicitly in this forecast.

3. Loss Factor Assumptions. The loss factors are important to convert the sales forecast to energy requirements. We use a historical average loss factor for each legal entity, and assume it will not change in the future.

B.8 Forecast Coordination

Xcel Energy reports its energy and peak demand forecasts to the Mid-Continent Area Power Pool (MAPP) as a requirement of membership. MAPP then combines the forecasts of all its member utilities. Xcel Energy also reports its forecast to the Public Service Commission of Wisconsin as part of its Strategic Energy Assessment (SEA) process. In this process, the Wisconsin portion of the total Xcel Energy system load is combined with other Wisconsin electric utilities to form a statewide Wisconsin forecast.

B.9 Methodology Changes

The risk assessment methodologies are the same methodologies that were used to develop the forecasts and risk assessment presented in the Company's forecast in the November 2006 Base Load Certificate of Need Filing[2] and the 2004 Resource Plan filing, with the exception of two changes. The first is a change in the number of historical data observations that were included in the peak demand forecast model. For the 2004 Resource Plan filing and the November 2006 Base Load

[2] The last two Certificates of Need filed by Xcel Energy - the Base Load and the Grand Meadow Wind Farm CONs (Dockets E002/CN-06-1518 and E002/CN-07-873 respectively) both used the same forecast.

Certificate of Need Filing, the peak demand model used explanatory data beginning in 1993. In the forecast used in this filing and the 2007 Resource Plan ("2007 Resource Plan Forecast") the peak demand model utilized data beginning in 1998. The second is how DSM is accounted for as explained below.

B.9.1 Demand-Side Management Programs

Our 2007 Resource Plan outlines a change we made to how we previously accounted for demand-side management ("DSM") in our resource plan. In past forecasts, embedded DSM from past programs was included in the forecast, but the forecast did not incorporate estimated savings from future DSM programs. Future DSM savings were made as an adjustment during modeling. In determining the forecasts in the new Resource Plan, we made adjustments to the forecasts to account for future DSM savings and no longer make adjustments during modeling.

The regression model results for the residential and commercial and industrial classes are reduced to account for the expected incremental impacts of DSM programs. The annual forecast impact of the new DSM programs (excluding Saver's Switch), was developed by our DSM Regulatory Strategy and Planning Department. Class from calendar month energy to billing month sales volumes converts the impacts. The resulting sales volumes are used to reduce the class level sales forecasts that result from the regression modeling process. Impacts from all program installations through 2006 are assumed embedded in the historical data, so only new program installations are included in the DSM adjustment.

The DSM adjustment was made to reflect compliance with Minnesota's new Renewable Energy Standard ("RES") requirements outlined in the Next Generation Energy Act of 2007. The Act seeks to achieve a statewide energy conservation goal of 1.5 percent of retail sales, recognizing that both direct and indirect energy conservation programs can help achieve this goal, and requires utilities to achieve a minimum amount of savings from direct programs at 1.0 percent by 2010. Utilities may include "indirect & other" projects to provide energy savings above the required 1.0 percent. The Company's current Conservation Improvement Program ("CIP") activities currently reduce annual retail sales by an estimated 0.8 percent. To comply with the RES, we proposed in the 2007 Resource Plan a 1.1 percent energy reduction plan and have assumed that energy savings goal in the DSM adjustment. The 1.1 percent energy savings is subtracted from the Minnesota jurisdictional sales forecast. The system load management savings estimates at peak demand are then applied to arrive at a "net" peak from the "base" peak.

B.10 Comparison Between Current and Previous Forecast

Due to our experiences in obtaining short-term capacity purchases, in 2004 we switched from using the 50 percent demand (MW) probability forecast for capacity planning to use the 90 percent demand (MW) probability forecast. In doing so, we also modified how we account for estimated short-term purchases available from the market and now include them in our generation assessment. This methodology change has been used in all Certificates of Need submitted since then and also in Xcel Energy's recently submitted 2007 Resource Plan filing.

Under this modified approach, we determined the amount of accredited short-term resources that we expected we would reasonably be able to obtain in any given season. We have determined that this accredited short-term resources capacity is 750 MW based on the transmission paths that we currently control or believe that we could control, as well as the estimated transfer capability into MAPP from the rest of MISO. We set this amount as our baseline level of short-term capacity and add it to our total capability to determine the gap between our load and resources. We then compare our increased capability against our 90 percent forecast level to ensure that we were acquiring sufficient resources to meet our actual peak.

Planning for capacity to the 90 percent forecast enables us to more confidently meet our "obligation to serve" as required by Minn. Stat § 216B.04.

B.10.1 Energy Comparison (50th Percentile Forecast)

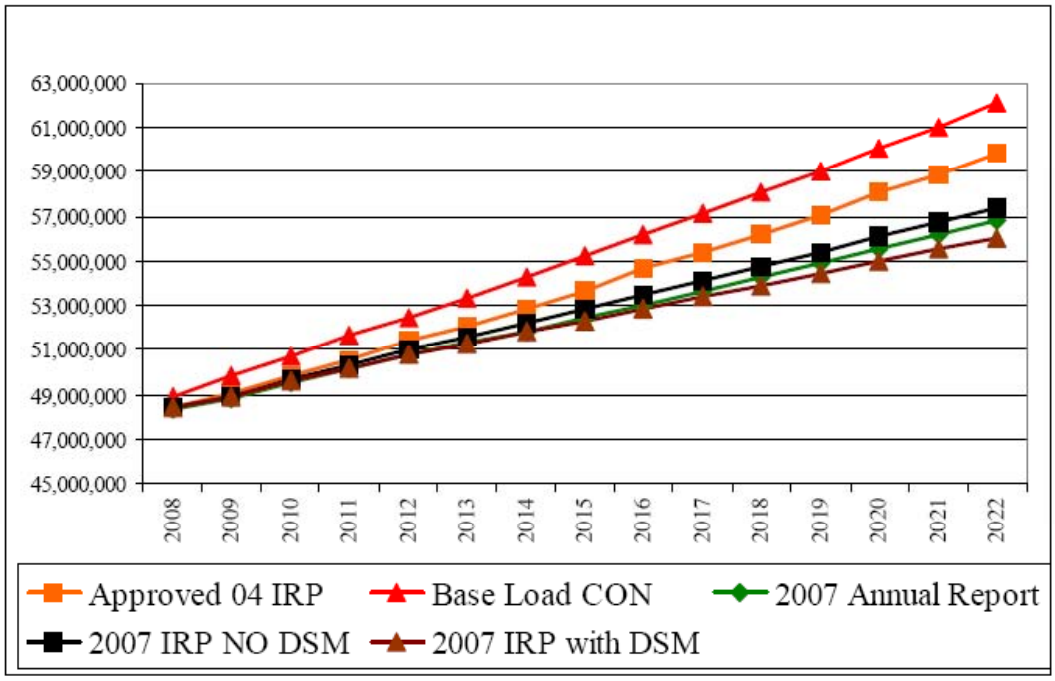
In the forecast used in this filing, ("2007 Resource Plan" forecast or "current forecast" – which includes the 1.1. percent DSM adjustment), the 2010 estimate of native energy requirements is 49,573,779 MWh compared to 50,705,794 MWh that was estimated in the forecast used in the 2006 Base Load CON Forecast (referred to as the "previous" forecast).

The current forecast of energy increases at an average annual rate of 1.1 percent, while the previous forecast increased at an average annual rate of 1.7 percent. This difference is affected by how DSM is handled though between the two forecasts, as well as new loss factors and lower than expected 2006 actual sales as compared to forecast.

For 2010, the current forecast is 1,132,015 MWh, or 2.2 percent lower than the previous forecast. The 2015 estimate of native energy requirements in the current forecast is 52,314,897 MWh compared to 55,244,670 MWh that was estimated in the previous forecast. For 2015, the current forecast is 2,929,733 MWh, or 5.3 percent lower than the previous forecast. Comparisons of the base energy

forecasts (50th percentile forecast) with and without DSM referenced above are found in Figure B.10.1. Copies of the 50th percentile forecast and the 90th percentile forecasts in graphic and tabular format are found in section B.12 Forecast Comparisons for comparison purposes.

Figure B.10.1
Comparison of Current and Previous Energy Forecasts

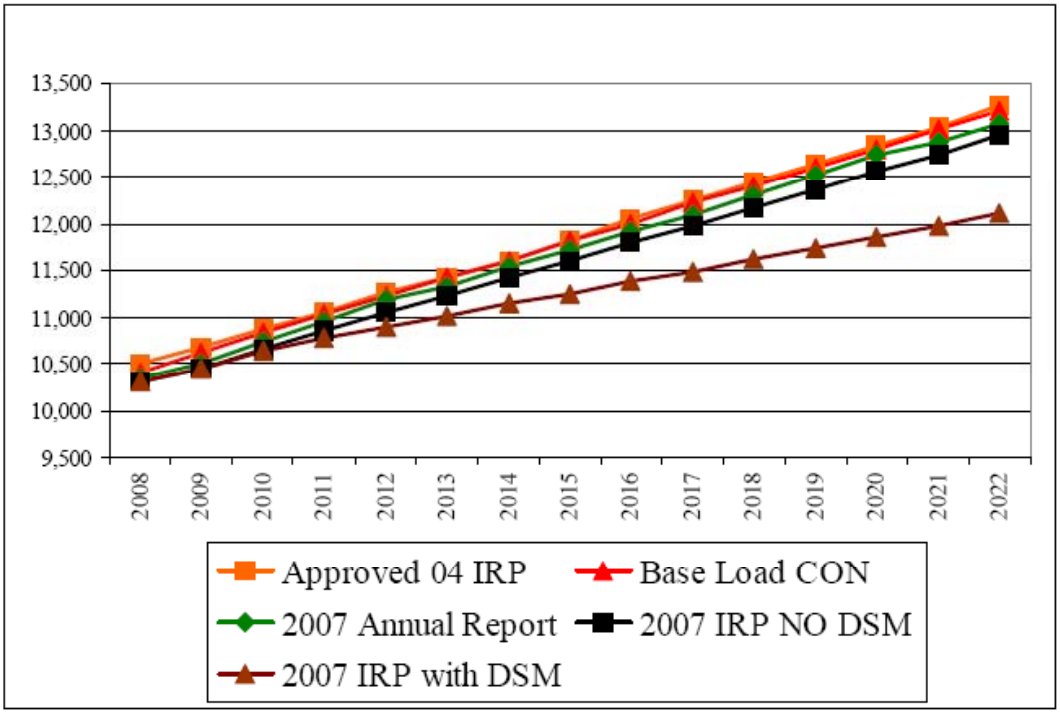


B.10.2 Peak Demand Comparison (90th Percentile Forecast)

In the current forecast, which includes a 1.1% DSM Adjustment, the 2010 estimate of base peak demand is 10,630 MW compared to 10,832 MW that was estimated in the previous forecast. For 2010, the current forecast is 202 MW, or 1.9 percent lower than the previous forecast. The 2015 estimate of Peak Demand in the current forecast is 11,250 MW compared to 11,816 MW that was estimated in the previous forecast. For 2015, the current forecast is 566 MW, or 4.8 percent lower than the previous forecast.

The current forecast of base peak demand increases at an average annual rate of 1.2 percent, while the previous forecast increased at an average annual rate of 1.7 percent. Comparisons of the current and previous base peak demand forecasts (90th percentile forecast) are found in Figure B.10.2. Copies of the 50th percentile forecast and the 90th percentile forecasts in graphic and tabular format are found in Section B.12 Forecast Comparisons for comparison purposes.

Figure B.10.2
Comparison of Current and Previous Demand Forecasts



Figures 10.1 and 10.2 above compare the peak demand and energy of the Company's current forecast with the forecasts approved in the 2004 Resource Plan, the Base Load CON filed in November of 2006 and the Electric Utility Annual Report filed in mid 2007. We have also included a comparison of the energy and demand forecasts with and without DSM for direct comparison to previous forecasts (which did not include the DSM adjustments). Figure 10.1 indicates that the energy forecast (without DSM) is slightly higher than the forecast reported in our 2007 Annual Electric Utility Report, but lower than the forecast approved in our 2004 Resource Plan. This is due to a reduction in some economic indicators since the 2004 Resource Plan forecast was produced. Figure 10.2 indicates that there has been very little change in the demand forecast since previous forecasts. The new demand forecast without DSM is slightly lower than the previous demand forecasts.

After accounting for the DSM, the average annual growth rates in the forecasts are similar to the average annual growth rates of previous forecasts. The change in DSM methodology reduces the forecast needs, but other factors also contribute, including updated loss factors that are lower than previous forecasts, some key variables being less optimistic in this forecast, and weather normalized actual sales for 2006, which were lower than forecast.

B.11 FORECASTING BASE LOAD DATA SET

B.11.1 Annual Electric Consumption

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Annual Electric Consumption (MWh)

	Farm	Irrigation	Residential	Commercial	Mining	Industrial	Street Lighting	Other	Total	Loss and Company Use	Total Native Requirements
1996	*NA*	*NA*	9,846,683	6,090,893	*NA*	18,559,078	162,829	901,219	35,560,702	3,351,548	38,912,250
1997	*NA*	*NA*	9,790,326	5,906,731	*NA*	19,322,224	168,560	542,548	35,730,389	3,770,864	39,501,253
1998	*NA*	*NA*	10,126,591	5,999,443	*NA*	20,078,399	169,440	822,445	37,196,318	3,495,771	40,692,089
1999	*NA*	*NA*	10,400,723	6,132,930	*NA*	20,290,272	170,527	791,416	37,785,868	3,430,442	41,216,310
2000	*NA*	*NA*	10,768,710	6,637,476	*NA*	20,684,275	172,961	823,692	39,087,114	3,154,430	42,241,544
2001	*NA*	*NA*	11,016,223	15,716,290	*NA*	11,735,057	176,470	859,435	39,503,475	3,326,283	42,829,758
2002	*NA*	*NA*	11,656,830	14,794,020	*NA*	12,870,013	177,553	945,011	40,443,427	3,336,657	43,780,084
2003	*NA*	*NA*	11,662,067	16,579,354	*NA*	11,443,959	177,054	954,164	40,816,598	2,916,803	43,733,401
2004	*NA*	*NA*	11,402,028	16,644,896	*NA*	11,708,988	188,087	1,098,171	41,042,169	2,347,910	43,390,079
2005	*NA*	*NA*	12,105,594	18,272,282	*NA*	11,110,675	184,643	1,303,511	42,976,705	1,780,450	44,757,155
2006	*NA*	*NA*	12,147,178	18,276,180	*NA*	11,354,870	192,808	1,651,632	43,622,668	2,495,690	46,118,358
2007	*NA*	*NA*	12,235,435	18,422,074	*NA*	11,654,626	193,779	1,672,093	44,178,008	3,534,712	47,712,720
2008	*NA*	*NA*	12,463,570	18,741,587	*NA*	11,866,069	195,746	1,523,642	44,790,612	3,582,601	48,373,213
2009	*NA*	*NA*	12,676,493	18,981,326	*NA*	12,091,019	197,743	1,314,487	45,261,068	3,620,958	48,882,025
2010	*NA*	*NA*	12,929,132	19,202,375	*NA*	12,242,683	199,771	1,328,577	45,902,538	3,671,241	49,573,779
2011	*NA*	*NA*	13,176,454	19,409,643	*NA*	12,332,924	201,831	1,341,159	46,462,011	3,715,285	50,177,296
2012	*NA*	*NA*	13,438,778	19,607,058	*NA*	12,405,475	203,925	1,353,092	47,008,328	3,756,382	50,764,710
2013	*NA*	*NA*	13,650,692	19,795,807	*NA*	12,468,612	206,053	1,362,114	47,483,278	3,795,850	51,279,128
2014	*NA*	*NA*	13,872,521	19,977,834	*NA*	12,526,231	208,215	1,371,390	47,956,191	3,833,127	51,789,318
2015	*NA*	*NA*	14,098,668	20,163,457	*NA*	12,589,898	210,414	1,380,892	48,443,329	3,871,568	52,314,897
2016	*NA*	*NA*	14,348,678	20,352,722	*NA*	12,647,809	212,649	1,390,660	48,952,517	3,909,774	52,862,291
2017	*NA*	*NA*	14,557,183	20,537,303	*NA*	12,716,782	214,922	1,400,597	49,426,788	3,949,241	53,376,029
2018	*NA*	*NA*	14,788,499	20,725,003	*NA*	12,782,520	217,234	1,410,813	49,924,068	3,988,475	53,912,542
2019	*NA*	*NA*	15,019,924	20,914,011	*NA*	12,850,648	219,586	1,421,279	50,425,448	4,028,091	54,453,539
2020	*NA*	*NA*	15,266,853	21,097,745	*NA*	12,922,115	221,979	1,432,038	50,940,731	4,066,747	55,007,477
2021	*NA*	*NA*	15,470,229	21,275,268	*NA*	13,001,600	224,415	1,442,992	51,414,503	4,106,184	55,520,687
2022	*NA*	*NA*	15,698,514	21,457,477	*NA*	13,076,931	226,894	1,454,253	51,914,068	4,145,626	56,059,694

B.11.1 Annual Electric Consumption – Continued

NSPM 2007 Resource Plan

Xcel Energy
State of Minnesota
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Annual Electric Consumption (MWh)

	Farm	Irrigation	Residential	Commercial	Mining	Industrial	Street Lighting	Other	Total Retail
1996	*NA*	*NA*	6,958,068	4,489,648	*NA*	14,804,136	120,454	130,446	26,502,752
1997	*NA*	*NA*	6,969,183	4,345,002	*NA*	15,381,278	125,384	123,757	26,944,604
1998	*NA*	*NA*	7,281,178	4,380,415	*NA*	15,941,944	126,008	117,103	27,846,648
1999	*NA*	*NA*	7,501,113	4,470,016	*NA*	16,078,335	125,845	116,404	28,291,713
2000	*NA*	*NA*	7,785,498	4,843,242	*NA*	16,401,555	128,075	115,585	29,273,955
2001	*NA*	*NA*	8,031,583	13,039,381	*NA*	8,355,790	130,612	117,940	29,675,306
2002	*NA*	*NA*	8,487,490	12,080,326	*NA*	9,369,199	130,657	109,500	30,177,172
2003	*NA*	*NA*	8,482,571	12,300,171	*NA*	9,387,479	129,473	118,286	30,417,981
2004	*NA*	*NA*	8,289,361	12,375,215	*NA*	9,489,401	139,813	109,413	30,403,203
2005	*NA*	*NA*	8,841,946	13,640,413	*NA*	8,993,804	135,989	100,894	31,713,045
2006	*NA*	*NA*	8,876,545	13,677,161	*NA*	9,129,744	143,664	99,422	31,926,536
2007	*NA*	*NA*	8,906,363	13,703,963	*NA*	9,345,179	143,423	101,588	32,200,517
2008	*NA*	*NA*	9,094,793	13,987,609	*NA*	9,550,680	144,656	101,623	32,879,362
2009	*NA*	*NA*	9,265,319	14,182,109	*NA*	9,747,577	145,900	101,588	33,442,494
2010	*NA*	*NA*	9,471,993	14,349,326	*NA*	9,868,097	147,155	101,588	33,938,159
2011	*NA*	*NA*	9,673,218	14,510,516	*NA*	9,930,964	148,421	101,588	34,364,708
2012	*NA*	*NA*	9,888,700	14,658,365	*NA*	9,976,815	149,697	101,623	34,775,201
2013	*NA*	*NA*	10,057,047	14,806,634	*NA*	10,016,272	150,985	101,588	35,132,526
2014	*NA*	*NA*	10,234,785	14,940,962	*NA*	10,048,588	152,283	101,588	35,478,206
2015	*NA*	*NA*	10,416,662	15,077,232	*NA*	10,086,163	153,593	101,588	35,835,238
2016	*NA*	*NA*	10,622,204	15,211,838	*NA*	10,116,198	154,914	101,623	36,206,776
2017	*NA*	*NA*	10,787,353	15,350,131	*NA*	10,157,620	156,246	101,588	36,552,938
2018	*NA*	*NA*	10,974,984	15,486,011	*NA*	10,192,334	157,590	101,588	36,912,506
2019	*NA*	*NA*	11,162,424	15,619,841	*NA*	10,227,951	158,945	101,588	37,270,748
2020	*NA*	*NA*	11,363,569	15,741,919	*NA*	10,265,692	160,312	101,623	37,633,114
2021	*NA*	*NA*	11,523,331	15,866,801	*NA*	10,312,843	161,690	101,588	37,966,254
2022	*NA*	*NA*	11,707,438	15,990,601	*NA*	10,355,137	163,081	101,588	38,317,845

B.11.2 Number of Customers By Class

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)

Number of Customers

	Farm	Irrigation	Residential	Commercial	Mining	Industrial	Street Lighting	Other	Total
1996	*NA*	*NA*	1,234,321	142,008	*NA*	8,596	2,910	2,849	1,390,684
1997	*NA*	*NA*	1,280,816	148,848	*NA*	9,653	3,371	2,905	1,445,593
1998	*NA*	*NA*	1,292,243	150,918	*NA*	10,144	3,331	2,912	1,459,548
1999	*NA*	*NA*	1,313,048	155,891	*NA*	10,423	2,330	2,895	1,484,587
2000	*NA*	*NA*	1,328,936	157,909	*NA*	9,382	3,623	2,832	1,502,682
2001	*NA*	*NA*	1,345,077	170,154	*NA*	752	3,836	2,833	1,522,652
2002	*NA*	*NA*	1,361,938	173,240	*NA*	763	4,009	2,838	1,542,788
2003	*NA*	*NA*	1,379,851	175,484	*NA*	753	3,784	2,810	1,562,682
2004	*NA*	*NA*	1,404,993	179,326	*NA*	769	4,299	2,813	1,592,200
2005	*NA*	*NA*	1,389,605	176,358	*NA*	616	4,290	2,716	1,573,585
2006	*NA*	*NA*	1,413,729	180,050	*NA*	599	4,430	2,746	1,601,554
2007	*NA*	*NA*	1,427,109	182,067	*NA*	616	4,508	2,734	1,617,034
2008	*NA*	*NA*	1,442,310	184,642	*NA*	616	4,597	2,712	1,634,877
2009	*NA*	*NA*	1,458,898	187,332	*NA*	616	4,696	2,690	1,654,232
2010	*NA*	*NA*	1,476,028	190,075	*NA*	616	4,799	2,669	1,674,187
2011	*NA*	*NA*	1,492,801	192,713	*NA*	616	4,900	2,648	1,693,678
2012	*NA*	*NA*	1,509,075	195,275	*NA*	616	4,999	2,627	1,712,591
2013	*NA*	*NA*	1,524,929	197,769	*NA*	616	5,094	2,606	1,731,013
2014	*NA*	*NA*	1,540,505	200,227	*NA*	616	5,188	2,585	1,749,122
2015	*NA*	*NA*	1,556,433	202,738	*NA*	616	5,284	2,565	1,767,636
2016	*NA*	*NA*	1,572,448	205,257	*NA*	616	5,381	2,545	1,786,247
2017	*NA*	*NA*	1,588,406	207,766	*NA*	616	5,477	2,525	1,804,790
2018	*NA*	*NA*	1,604,723	210,334	*NA*	616	5,575	2,505	1,823,754
2019	*NA*	*NA*	1,620,658	212,850	*NA*	616	5,671	2,486	1,842,282
2020	*NA*	*NA*	1,636,294	215,323	*NA*	616	5,765	2,467	1,860,464
2021	*NA*	*NA*	1,652,011	217,809	*NA*	616	5,860	2,448	1,878,743
2022	*NA*	*NA*	1,667,930	220,324	*NA*	616	5,956	2,429	1,897,255

B.11.2 Number of Customers By Class – Continued

NSPM 2007 Resource Plan

Xcel Energy
State of Minnesota Electric
Certificate of Need Filing
Median Forecast (50th Percentile)

Number of Customers

	Farm	Irrigation	Residential	Commercial	Mining	Industrial	Street Lighting	Other	Total
1996	NA	NA	928,009	95,911	NA	6,217	2,004	2,192	1,034,333
1997	NA	NA	970,762	102,191	NA	7,065	2,470	2,257	1,084,745
1998	NA	NA	977,119	103,315	NA	7,494	2,404	2,232	1,092,564
1999	NA	NA	993,337	107,118	NA	7,908	1,424	2,214	1,112,001
2000	NA	NA	1,006,613	107,679	NA	6,952	2,629	2,160	1,126,033
2001	NA	NA	1,017,202	116,720	NA	603	2,791	2,162	1,139,478
2002	NA	NA	1,029,634	118,687	NA	608	2,945	2,170	1,154,044
2003	NA	NA	1,043,231	120,223	NA	595	2,712	2,142	1,168,903
2004	NA	NA	1,062,137	122,902	NA	586	3,188	2,140	1,190,953
2005	NA	NA	1,047,452	119,935	NA	485	3,151	2,093	1,173,116
2006	NA	NA	1,065,337	122,406	NA	461	3,276	2,062	1,193,542
2007	NA	NA	1,075,599	123,562	NA	482	3,331	2,055	1,205,028
2008	NA	NA	1,087,686	125,157	NA	482	3,402	2,033	1,218,760
2009	NA	NA	1,101,080	126,924	NA	482	3,484	2,011	1,233,982
2010	NA	NA	1,114,994	128,760	NA	482	3,570	1,990	1,249,796
2011	NA	NA	1,128,548	130,548	NA	482	3,654	1,969	1,265,202
2012	NA	NA	1,141,698	132,283	NA	482	3,736	1,948	1,280,147
2013	NA	NA	1,154,471	133,969	NA	482	3,816	1,927	1,294,665
2014	NA	NA	1,166,977	135,619	NA	482	3,894	1,906	1,308,878
2015	NA	NA	1,179,834	137,315	NA	482	3,974	1,886	1,323,492
2016	NA	NA	1,192,793	139,025	NA	482	4,055	1,866	1,338,221
2017	NA	NA	1,205,720	140,731	NA	482	4,136	1,846	1,352,915
2018	NA	NA	1,219,050	142,489	NA	482	4,219	1,826	1,368,068
2019	NA	NA	1,231,996	144,197	NA	482	4,300	1,807	1,382,783
2020	NA	NA	1,244,656	145,868	NA	482	4,379	1,788	1,397,173
2021	NA	NA	1,257,422	147,552	NA	482	4,459	1,769	1,411,684
2022	NA	NA	1,270,488	149,276	NA	482	4,541	1,750	1,426,537

B.11.3 Annual Base Peak Demand By Customer Class

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Annual Base Peak Demand (Mw) by Customer Class

		Farm	Irrigation	Residential	Commercial	Mining	Industrial	Street Lighting	Other	System Peak Demand Mw
NET PEAK	**1996**	71	NA	2,421	1,402	10	3,416	NA	168	7,488
	1997	68	NA	2,335	1,318	11	3,466	NA	155	7,353
	1998	68	NA	2,450	1,345	9	3,638	NA	149	7,659
	1999	NA	NA	2,669	1,405	NA	3,756	NA	160	7,990
	2000	NA	NA	2,655	1,461	NA	3,674	NA	146	7,936
	2001	NA	NA	3,087	1,578	NA	3,581	NA	103	8,349
	2002	NA	NA	2,773	2,831	NA	2,383	NA	252	8,239
	2003	NA	NA	3,074	3,113	NA	1,933	NA	161	8,281
	2004	NA	NA	3,055	3,164	NA	2,173	NA	204	8,596
	2005	NA	NA	3,222	3,174	NA	1,884	NA	221	8,501
	2006	NA	NA	3,274	3,394	NA	2,059	NA	299	9,026
	2007	NA	NA	3,419	3,545	NA	2,150	NA	312	9,427
	2008	NA	NA	3,532	3,661	NA	2,221	NA	323	9,737
BASE PEAK	**2009**	NA	NA	3,584	3,716	NA	2,254	NA	327	9,881
	2010	NA	NA	3,649	3,783	NA	2,295	NA	333	10,060
	2011	NA	NA	3,696	3,832	NA	2,325	NA	338	10,190
	2012	NA	NA	3,740	3,877	NA	2,352	NA	342	10,310
	2013	NA	NA	3,777	3,916	NA	2,376	NA	345	10,414
	2014	NA	NA	3,820	3,960	NA	2,402	NA	349	10,531
	2015	NA	NA	3,859	4,000	NA	2,427	NA	352	10,639
	2016	NA	NA	3,899	4,041	NA	2,452	NA	356	10,748
	2017	NA	NA	3,933	4,078	NA	2,474	NA	359	10,844
	2018	NA	NA	3,977	4,123	NA	2,501	NA	363	10,965
	2019	NA	NA	4,016	4,163	NA	2,526	NA	367	11,072
	2020	NA	NA	4,054	4,202	NA	2,549	NA	370	11,176
	2021	NA	NA	4,086	4,236	NA	2,570	NA	373	11,265
	2022	NA	NA	4,128	4,279	NA	2,596	NA	377	11,379

The historical peaks by class in this table sum to the Net (interrupted) peak rather than Base (uninterrupted) peak. The forecasted peaks by class sum to the Base peak forecast.

In the Monthly Native Demand and Energy Table B.11.4, the historical monthly peaks are Base peaks. Therefore, the historical system values do not tie between Table B.11.3 and Table B.11.4.

B.11.4 Monthly Native Energy and Demand Requirements

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Jan-96	3,409,149	5,813	31	78.8%
Feb-96	3,122,223	5,955	29	75.3%
Mar-96	3,222,120	5,568	31	77.8%
Apr-96	2,947,510	5,129	30	79.8%
May-96	2,992,877	5,225	31	77.0%
Jun-96	3,351,580	7,624	30	61.1%
Jul-96	3,434,739	7,325	31	63.0%
Aug-96	3,636,362	7,687	31	63.6%
Sep-96	3,146,268	7,093	30	61.6%
Oct-96	3,124,517	5,417	31	77.5%
Nov-96	3,153,288	5,666	30	77.3%
Dec-96	3,371,617	5,869	31	77.2%
Jan-97	3,495,291	5,856	31	80.2%
Feb-97	3,041,215	5,555	28	81.5%
Mar-97	3,191,399	5,332	31	80.4%
Apr-97	2,882,858	5,189	30	77.2%
May-97	2,991,849	5,099	31	78.9%
Jun-97	3,437,381	7,271	30	65.7%
Jul-97	3,786,351	7,767	31	65.5%
Aug-97	3,587,471	6,716	31	71.8%
Sep-97	3,254,699	6,141	30	73.6%
Oct-97	3,263,444	5,864	31	74.8%
Nov-97	3,192,368	5,631	30	78.7%
Dec-97	3,376,927	5,787	31	78.4%
Jan-98	3,448,048	5,877	31	78.9%
Feb-98	3,022,832	5,608	28	80.2%
Mar-98	3,299,215	5,506	31	80.5%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Apr-98	3,001,079	5,251	30	79.4%
May-98	3,328,372	7,142	31	62.6%
Jun-98	3,441,411	7,099	30	67.3%
Jul-98	3,979,545	8,179	31	65.4%
Aug-98	3,922,566	7,268	31	72.5%
Sep-98	3,455,777	6,682	30	71.8%
Oct-98	3,237,478	5,466	31	79.6%
Nov-98	3,136,287	5,598	30	77.8%
Dec-98	3,419,479	6,187	31	74.3%
Jan-99	3,585,110	6,138	31	78.5%
Feb-99	3,061,339	5,670	28	80.3%
Mar-99	3,255,083	5,470	31	80.0%
Apr-99	3,025,556	5,169	30	81.3%
May-99	3,218,400	5,806	31	74.5%
Jun-99	3,581,246	7,495	30	66.4%
Jul-99	4,250,059	8,735	31	65.4%
Aug-99	3,850,480	7,814	31	66.2%
Sep-99	3,363,251	7,675	30	60.9%
Oct-99	3,291,632	5,501	31	80.4%
Nov-99	3,182,850	5,885	30	75.1%
Dec-99	3,551,303	6,422	31	74.3%
Jan-00	3,586,329	5,985	31	80.5%
Feb-00	3,042,834	5,818	29	75.1%
Mar-00	3,306,723	5,409	31	82.2%
Apr-00	3,147,526	5,422	30	80.6%
May-00	3,439,965	6,563	31	70.4%
Jun-00	3,550,819	7,545	30	65.4%
Jul-00	4,060,805	7,816	31	69.8%
Aug-00	4,151,284	8,189	31	68.1%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Sep-00	3,407,477	6,720	30	70.4%
Oct-00	3,362,896	5,675	31	79.6%
Nov-00	3,391,085	6,053	30	77.8%
Dec-00	3,793,801	6,557	31	77.8%
Jan-01	3,639,735	6,144	31	79.6%
Feb-01	3,327,152	6,112	28	81.0%
Mar-01	3,414,582	5,624	31	81.6%
Apr-01	3,150,897	5,594	30	78.2%
May-01	3,412,524	7,200	31	63.7%
Jun-01	3,728,184	8,061	30	64.2%
Jul-01	4,347,736	9,001	31	64.9%
Aug-01	4,271,909	9,236	31	62.2%
Sep-01	3,382,565	6,924	30	67.9%
Oct-01	3,361,640	5,740	31	78.7%
Nov-01	3,266,364	6,005	30	75.5%
Dec-01	3,526,470	6,012	31	78.8%
Jan-02	3,622,279	6,187	31	78.7%
Feb-02	3,163,001	5,872	28	80.2%
Mar-02	3,548,998	5,946	31	80.2%
Apr-02	3,272,927	6,221	30	73.1%
May-02	3,348,877	7,013	31	64.2%
Jun-02	3,937,321	8,281	30	66.0%
Jul-02	4,564,178	8,924	31	68.7%
Aug-02	4,024,109	7,465	31	72.5%
Sep-02	3,707,000	8,192	30	62.8%
Oct-02	3,529,247	5,929	31	80.0%
Nov-02	3,411,544	6,070	30	78.1%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Dec-02	3,650,602	6,386	31	76.8%
Jan-03	3,803,608	6,371	31	80.2%
Feb-03	3,384,792	6,236	28	80.8%
Mar-03	3,527,760	5,954	31	79.6%
Apr-03	3,287,588	5,755	30	79.3%
May-03	3,310,402	5,892	31	75.5%
Jun-03	3,649,429	7,760	30	65.3%
Jul-03	4,218,642	8,066	31	70.3%
Aug-03	4,354,499	8,868	31	66.0%
Sep-03	3,561,053	7,819	30	63.3%
Oct-03	3,486,682	6,128	31	76.5%
Nov-03	3,425,474	6,136	30	77.5%
Dec-03	3,723,471	6,497	31	77.0%
Jan-04	3,943,515	6,653	31	79.7%
Feb-04	3,394,926	6,320	29	77.2%
Mar-04	3,564,881	5,941	31	80.7%
Apr-04	3,206,338	5,749	30	77.5%
May-04	3,448,170	6,240	31	74.3%
Jun-04	3,668,748	8,106	30	62.9%
Jul-04	4,191,224	8,665	31	65.0%
Aug-04	3,904,279	7,920	31	66.3%
Sep-04	3,826,641	8,029	30	66.2%
Oct-04	3,536,969	5,937	31	80.1%
Nov-04	3,502,014	6,224	30	78.1%
Dec-04	4,033,963	6,873	31	78.9%
Jan-05	3,882,624	6,636	31	78.6%
Feb-05	3,371,444	6,222	28	80.6%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Mar-05	3,638,633	5,996	31	81.6%
Apr-05	3,312,891	6,017	30	76.5%
May-05	3,458,752	6,055	31	76.8%
Jun-05	4,129,640	9,072	30	63.2%
Jul-05	4,643,177	8,945	31	69.8%
Aug-05	4,354,721	9,104	31	64.3%
Sep-05	3,785,401	7,512	30	70.0%
Oct-05	3,666,458	7,253	31	67.9%
Nov-05	3,526,905	6,466	30	75.8%
Dec-05	3,916,529	6,833	31	77.0%
Jan-06	4,080,982	6,689	31	82.0%
Feb-06	3,578,106	6,385	28	83.4%
Mar-06	3,671,298	6,093	31	81.0%
Apr-06	3,462,513	6,062	30	79.3%
May-06	3,663,096	7,024	31	70.1%
Jun-06	4,002,806	8,596	30	64.7%
Jul-06	4,562,949	9,314	31	65.8%
Aug-06	4,502,426	9,035	31	67.0%
Sep-06	3,829,688	8,268	30	64.3%
Oct-06	3,768,048	6,304	31	80.3%
Nov-06	3,755,432	6,387	30	81.7%
Dec-06	4,063,998	6,808	31	80.2%
Jan-07	4,032,030	6,597	31	82.1%
Feb-07	3,541,786	6,740	28	78.2%
Mar-07	3,930,805	6,297	31	83.9%
Apr-07	3,491,186	5,985	30	81.0%
May-07	3,843,306	7,273	31	71.0%
Jun-07	4,241,697	9,130	30	64.5%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Jul-07	4,660,851	9,427	31	66.5%
Aug-07	4,574,712	8,820	31	69.7%
Sep-07	3,760,865	8,093	30	64.5%
Oct-07	3,808,848	6,378	31	80.3%
Nov-07	3,781,794	6,486	30	81.0%
Dec-07	4,044,840	6,941	31	78.3%
Jan-08	4,048,374	6,804	31	80.0%
Feb-08	3,756,007	6,602	29	81.7%
Mar-08	4,097,462	6,234	31	88.3%
Apr-08	3,581,599	6,108	30	81.4%
May-08	3,961,273	7,336	31	72.6%
Jun-08	4,264,234	9,062	30	65.4%
Jul-08	4,753,717	9,737	31	65.6%
Aug-08	4,509,999	9,294	31	65.2%
Sep-08	3,624,922	8,300	30	60.7%
Oct-08	3,853,254	6,455	31	80.2%
Nov-08	3,881,438	6,566	30	82.1%
Dec-08	4,040,935	7,024	31	77.3%
Jan-09	4,057,907	6,892	31	79.1%
Feb-09	3,667,639	6,679	28	81.7%
Mar-09	4,183,623	6,298	31	89.3%
Apr-09	3,625,775	6,168	30	81.6%
May-09	3,954,579	7,445	31	71.4%
Jun-09	4,320,987	9,214	30	65.1%
Jul-09	4,793,735	9,881	31	65.2%
Aug-09	4,536,994	9,439	31	64.6%
Sep-09	3,808,954	8,500	30	62.2%
Oct-09	3,886,988	6,514	31	80.2%
Nov-09	3,932,047	6,620	30	82.5%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Dec-09	4,112,797	7,093	31	77.9%
Jan-10	4,113,762	6,946	31	79.6%
Feb-10	3,734,039	6,735	29	79.7%
Mar-10	4,261,141	6,346	31	90.2%
Apr-10	3,685,005	6,217	30	82.3%
May-10	4,017,079	7,571	31	71.3%
Jun-10	4,378,924	9,388	30	64.8%
Jul-10	4,846,619	10,060	31	64.8%
Aug-10	4,584,122	9,619	31	64.1%
Sep-10	3,855,009	8,697	30	61.6%
Oct-10	3,939,719	6,565	31	80.7%
Nov-10	3,988,476	6,673	30	83.0%
Dec-10	4,169,884	7,153	31	78.4%
Jan-11	4,161,358	6,979	31	80.1%
Feb-11	3,786,436	6,765	28	83.3%
Mar-11	4,322,479	6,369	31	91.2%
Apr-11	3,735,080	6,238	30	83.2%
May-11	4,070,465	7,660	31	71.4%
Jun-11	4,431,331	9,519	30	64.7%
Jul-11	4,897,367	10,190	31	64.6%
Aug-11	4,630,793	9,751	31	63.8%
Sep-11	3,897,804	8,862	30	61.1%
Oct-11	3,986,633	6,584	31	81.4%
Nov-11	4,037,785	6,691	30	83.8%
Dec-11	4,219,765	7,176	31	79.0%
Jan-12	4,210,136	7,004	31	80.8%
Feb-12	3,967,605	6,787	29	84.0%
Mar-12	4,331,690	6,381	31	91.2%
Apr-12	3,776,293	6,248	30	83.9%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
May-12	4,169,346	7,740	31	72.4%
Jun-12	4,475,697	9,639	30	64.5%
Jul-12	4,948,686	10,310	31	64.5%
Aug-12	4,685,762	9,874	31	63.8%
Sep-12	3,788,405	9,002	30	58.4%
Oct-12	4,056,480	6,586	31	82.8%
Nov-12	4,096,992	6,694	30	85.0%
Dec-12	4,257,618	7,184	31	79.7%
Jan-13	4,249,762	7,012	31	81.5%
Feb-13	3,876,018	6,794	28	84.9%
Mar-13	4,427,064	6,391	31	93.1%
Apr-13	3,821,958	6,257	30	84.8%
May-13	4,164,523	7,804	31	71.7%
Jun-13	4,527,857	9,745	30	64.5%
Jul-13	4,996,934	10,414	31	64.5%
Aug-13	4,724,620	9,978	31	63.6%
Sep-13	3,980,051	9,167	30	60.3%
Oct-13	4,073,404	6,608	31	82.9%
Nov-13	4,127,171	6,713	30	85.4%
Dec-13	4,309,766	7,210	31	80.3%
Jan-14	4,290,845	7,040	31	81.9%
Feb-14	3,915,835	6,819	29	82.5%
Mar-14	4,473,538	6,407	31	93.9%
Apr-14	3,860,460	6,271	30	85.5%
May-14	4,206,591	7,884	31	71.7%
Jun-14	4,572,042	9,862	30	64.4%
Jul-14	5,044,704	10,531	31	64.4%
Aug-14	4,770,149	10,098	31	63.5%
Sep-14	4,019,135	9,304	30	60.0%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Oct-14	4,114,722	6,614	31	83.6%
Nov-14	4,169,272	6,721	30	86.2%
Dec-14	4,352,024	7,222	31	81.0%
Jan-15	4,332,760	7,053	31	82.6%
Feb-15	3,955,841	6,831	28	86.2%
Mar-15	4,520,234	6,413	31	94.7%
Apr-15	3,900,144	6,277	30	86.3%
May-15	4,250,096	7,952	31	71.8%
Jun-15	4,618,055	9,969	30	64.3%
Jul-15	5,094,659	10,639	31	64.4%
Aug-15	4,817,943	10,209	31	63.4%
Sep-15	4,059,927	9,447	30	59.7%
Oct-15	4,157,350	6,621	31	84.4%
Nov-15	4,212,518	6,727	30	87.0%
Dec-15	4,395,371	7,234	31	81.7%
Jan-16	4,379,154	7,067	31	83.3%
Feb-16	4,137,546	6,843	29	86.9%
Mar-16	4,519,207	6,417	31	94.7%
Apr-16	3,935,719	6,278	30	87.1%
May-16	4,347,328	8,023	31	72.8%
Jun-16	4,659,290	10,079	30	64.2%
Jul-16	5,145,848	10,748	31	64.4%
Aug-16	4,874,140	10,322	31	63.5%
Sep-16	3,940,207	9,577	30	57.1%
Oct-16	4,226,149	6,615	31	85.9%
Nov-16	4,268,885	6,723	30	88.2%
Dec-16	4,428,820	7,234	31	82.3%
Jan-17	4,418,504	7,068	31	84.0%
Feb-17	4,036,736	6,843	28	87.8%

B.11.4 Monthly Native Energy and Dem-and Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Mar-17	4,614,669	6,421	31	96.6%
Apr-17	3,979,999	6,281	30	88.0%
May-17	4,337,876	8,080	31	72.2%
Jun-17	4,711,425	10,176	30	64.3%
Jul-17	5,195,951	10,844	31	64.4%
Aug-17	4,915,160	10,419	31	63.4%
Sep-17	4,142,547	9,738	30	59.1%
Oct-17	4,242,629	6,634	31	86.0%
Nov-17	4,298,799	6,739	30	88.6%
Dec-17	4,481,733	7,258	31	83.0%
Jan-18	4,461,556	7,093	31	84.5%
Feb-18	4,077,170	6,866	29	85.3%
Mar-18	4,661,921	6,435	31	97.4%
Apr-18	4,019,928	6,294	30	88.7%
May-18	4,381,834	8,162	31	72.2%
Jun-18	4,758,261	10,296	30	64.2%
Jul-18	5,247,309	10,965	31	64.3%
Aug-18	4,964,545	10,544	31	63.3%
Sep-18	4,184,445	9,880	30	58.8%
Oct-18	4,286,479	6,639	31	86.8%
Nov-18	4,343,089	6,746	30	89.4%
Dec-18	4,526,006	7,269	31	83.7%
Jan-19	4,505,725	7,106	31	85.2%
Feb-19	4,118,599	6,878	28	89.1%
Mar-19	4,710,351	6,441	31	98.3%
Apr-19	4,060,588	6,299	30	89.5%
May-19	4,426,619	8,232	31	72.3%
Jun-19	4,805,966	10,406	30	64.1%
Jul-19	5,298,921	11,072	31	64.3%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,

Base Peak Demand and Load Factors

	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Aug-19	5,014,215	10,654	31	63.3%
Sep-19	4,226,640	10,024	30	58.6%
Oct-19	4,329,680	6,645	31	87.6%
Nov-19	4,386,694	6,752	30	90.2%
Dec-19	4,569,540	7,280	31	84.4%
Jan-20	4,553,062	7,119	31	86.0%
Feb-20	4,307,813	6,888	29	89.9%
Mar-20	4,707,143	6,442	31	98.2%
Apr-20	4,096,527	6,298	30	90.3%
May-20	4,528,151	8,299	31	73.3%
Jun-20	4,847,804	10,511	30	64.1%
Jul-20	5,350,687	11,176	31	64.4%
Aug-20	5,071,472	10,762	31	63.3%
Sep-20	4,097,632	10,148	30	56.1%
Oct-20	4,400,552	6,636	31	89.1%
Nov-20	4,444,127	6,744	30	91.5%
Dec-20	4,602,507	7,276	31	85.0%
Jan-21	4,592,238	7,116	31	86.7%
Feb-21	4,199,808	6,884	28	90.8%
Mar-21	4,805,486	6,444	31	100.2%
Apr-21	4,140,610	6,299	30	91.3%
May-21	4,514,813	8,351	31	72.7%
Jun-21	4,899,607	10,600	30	64.2%
Jul-21	5,400,627	11,265	31	64.4%
Aug-21	5,112,194	10,853	31	63.3%

B.11.4 Monthly Native Energy and Demand Requirements – Continued

NSPM 2007 Resource Plan

Xcel Energy
NSP Electric - Total System
Certificate of Need Filing
Median Forecast (50th Percentile)
With 1.1% of Retail Sales DSM Adjustment

Monthly Native Energy Requirements,
Base Peak Demand and Load Factors

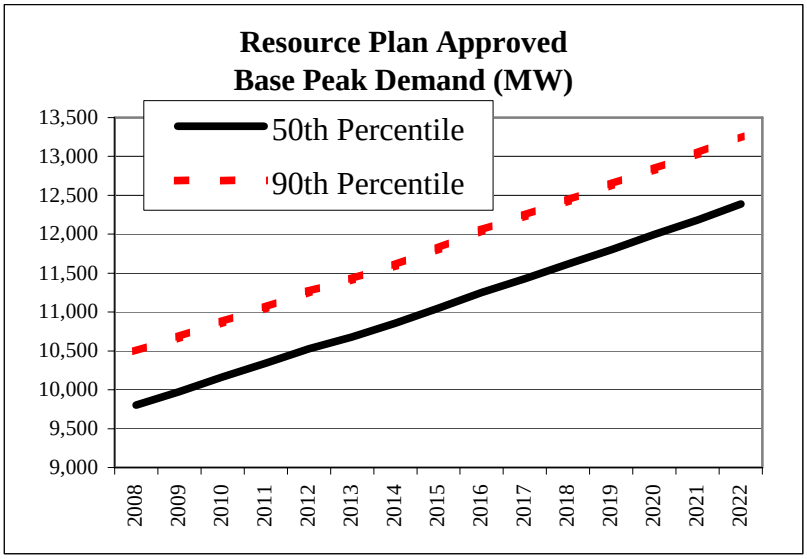
	Native Energy Requirements (MWh)	Base Peak Demand (MW)	Days	Load Factor
Sep-21	4,310,080	10,304	30	58.1%
Oct-21	4,415,732	6,653	31	89.2%
Nov-21	4,473,474	6,758	30	91.9%
Dec-21	4,656,020	7,297	31	85.8%
Jan-22	4,635,631	7,138	31	87.3%
Feb-22	4,240,539	6,905	28	91.4%
Mar-22	4,853,257	6,455	31	101.1%
Apr-22	4,181,011	6,308	30	92.1%
May-22	4,559,366	8,429	31	72.7%
Jun-22	4,946,900	10,716	30	64.1%
Jul-22	5,452,114	11,379	31	64.4%
Aug-22	5,161,820	10,972	31	63.2%
Sep-22	4,352,362	10,440	30	57.9%
Oct-22	4,459,383	6,655	31	90.1%
Nov-22	4,517,483	6,762	30	92.8%
Dec-22	4,699,828	7,305	31	86.5%

B.12 FORECAST COMPARISONS

NSP Total System Base Peak Demand (MW) and Net Energy Requirements (MWh)

NSP Resource Plan Comments, Developed February– March 2005

	50th percentile Annual Base Peak Demand (Mw)	90th percentile Annual Base Peak Demand (Mw)	50th percentile Annual Net Energy Requirements (Mwh)
2008	9,802	10,496	48,428,121
2009	9,975	10,679	49,042,914
2010	10,165	10,874	49,839,238
2011	10,341	11,058	50,585,761
2012	10,528	11,266	51,450,923
2013	10,682	11,425	52,066,570
2014	10,857	11,601	52,856,413
2015	11,049	11,818	53,678,550
2016	11,254	12,050	54,646,114
2017	11,431	12,239	55,358,388
2018	11,617	12,435	56,210,883
2019	11,801	12,638	57,072,089
2022	11,997	12,838	58,096,397
2021	12,183	13,039	58,879,521
2022	12,387	13,260	59,839,229
Compound Growth Rate 2008-2022	**1.7%**	**1.7%**	**1.5%**

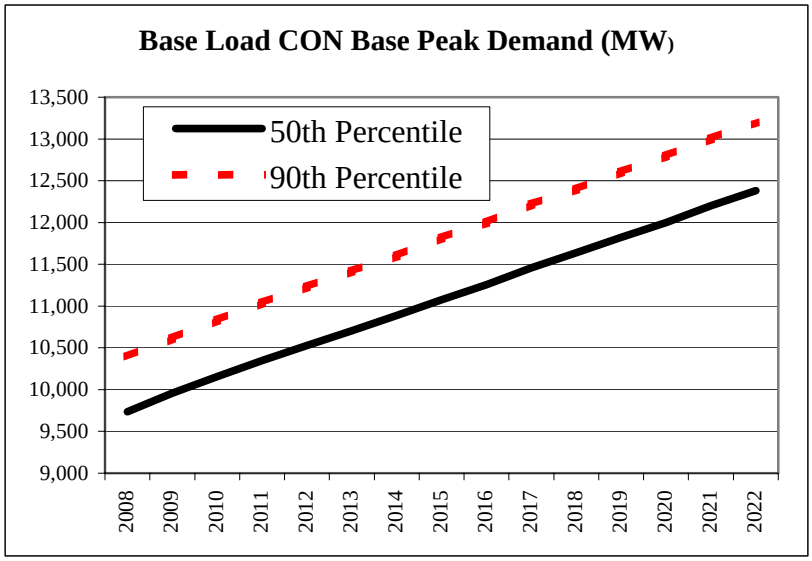


B.12 FORECAST COMPARISONS – Continued

NSP Total System Base Peak Demand (MW) and Net Energy Requirements (MWh)

Base Load CON, Developed September 2006

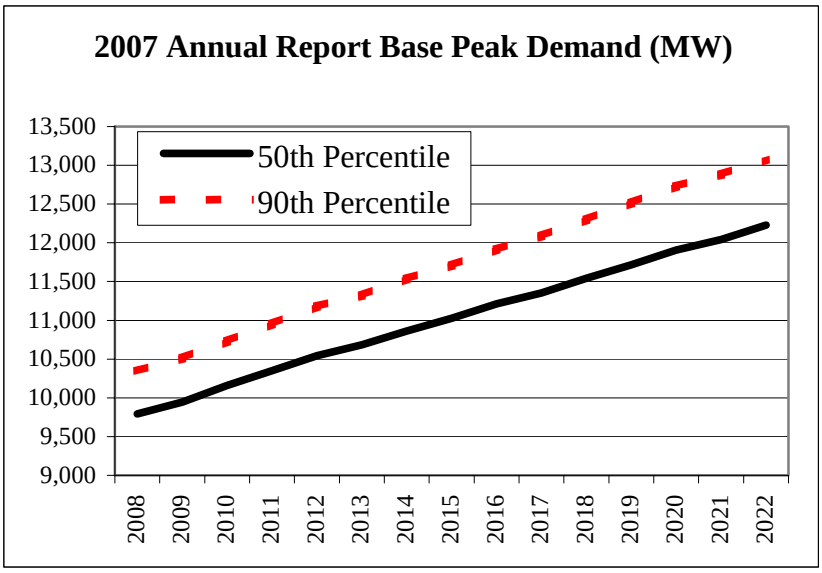
	50th percentile Annual Base Peak Demand (Mw)	90th percentile Annual Base Peak Demand (Mw)	50th percentile Annual Net Energy Requirements (Mwh)
2008	9,737	10,394	48,884,398
2009	9,959	10,611	49,811,120
2010	10,156	10,832	50,705,794
2011	10,348	11,038	51,625,282
2012	10,528	11,228	52,444,045
2013	10,706	11,418	53,352,100
2014	10,887	11,602	54,285,466
2015	11,076	11,816	55,244,670
2016	11,257	11,999	56,169,194
02017	11,460	12,217	57,126,151
2018	11,639	12,397	58,092,539
2019	11,824	12,602	59,065,704
2022	11,997	12,795	60,039,946
2021	12,201	13,003	61,041,701
2022	12,382	13,202	62,099,223
Compound Growth Rate: 2008-2022	**1.7%**	**1.7%**	**1.7%**



B.12 FORECAST COMPARISONS – Continued

NSP Total System Base Peak Demand (MW) and Net Energy Requirements (MWh)

2007 Electric Utility Annual Report, Developed March– May 2007			
	50th percentile Annual Base Peak Demand (MW)	90th percentile Annual Base Peak Demand (MW)	50th percentile Annual Net Energy Requirements (MWh)
2008	9,794	10,346	48,299,200
2009	9,947	10,509	48,829,622
2010	10,159	10,732	49,537,523
2011	10,350	10,952	50,169,349
2012	10,543	11,180	50,752,962
2013	10,684	11,319	51,310,171
2014	10,862	11,533	51,857,925
2015	11,027	11,708	52,419,640
2016	11,212	11,913	53,012,928
2017	11,353	12,087	53,629,066
2018	11,543	12,299	54,277,413
2019	11,718	12,513	54,923,440
2022	11,906	12,727	55,564,816
2021	12,042	12,879	56,174,843
2022	12,227	13,075	56,811,606
Compound Growth Rate: 2008 - 2022	**1.6%**	**1.7%**	**1.2%**

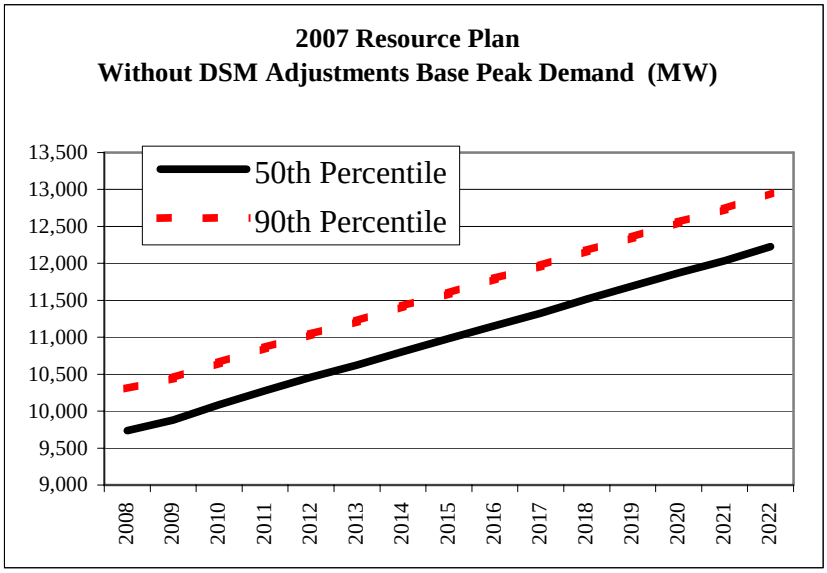


B.12 FORECAST COMPARISONS – Continued

NSP Total System Base Peak Demand (MW) and Net Energy Requirements (MWh)

2007 Resource Plan Forecast, Developed October–November (Without DSM Adjustments)

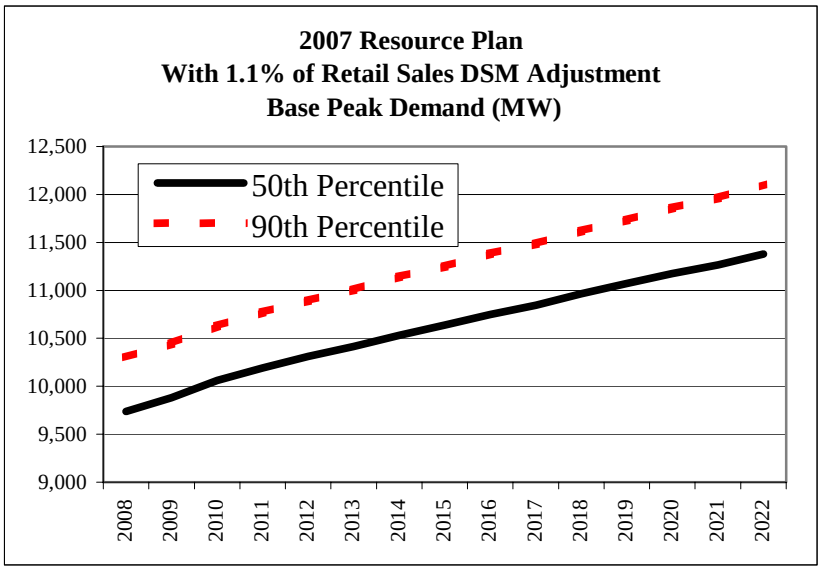
	50th percentile Annual Base Peak Demand (MW)	90th percentile Annual Base Peak Demand (MW)	50th percentile Annual Net Energy Requirements (MWh)
2008	9,737	10,302	48,373,213
2009	9,881	10,446	48,882,025
2010	10,087	10,656	49,644,192
2011	10,277	10,859	50,326,684
2012	10,459	11,042	50,998,180
2013	10,626	11,218	51,601,327
2014	10,808	11,420	52,204,471
2015	10,982	11,593	52,827,006
2016	11,158	11,793	53,475,257
2017	11,324	11,966	54,093,871
2018	11,515	12,169	54,739,404
2019	11,694	12,354	55,393,752
2022	11,871	12,555	56,065,456
2021	12,035	12,732	56,700,893
2022	12,226	12,952	57,366,641
Compound Growth Rate: 2008-2022	**1.6%**	**1.6%**	**1.2%**



B.12 FORECAST COMPARISONS – Continued

NSP Total System Base Peak Demand (MW) and Net Energy Requirements (MWh)

2007 Resource Plan Forecast, Developed October-November 2007 (Contains 1.0% of Retail Sales DSM Adjustment)			
	50th percentile Annual Base Peak Demand (MW)	90th percentile Annual Base Peak Demand (MW)	50th percentile Annual Net Energy Requirements (MWh)
2008	9,737	10,302	48,373,213
2009	9,881	10,446	48,882,025
2010	10,060	10,630	49,573,779
2011	10,190	10,773	50,177,296
2012	10,310	10,893	50,764,710
2013	10,414	11,006	51,279,128
2014	10,531	11,143	51,789,318
2015	10,639	11,250	52,314,897
2016	10,748	11,382	52,862,291
2017	10,844	11,487	53,376,029
2018	10,965	11,619	53,912,542
2019	11,072	11,732	54,453,539
2022	11,176	11,860	55,007,477
2021	11,265	11,961	55,520,687
2022	11,379	12,105	56,059,694
Compound Growth Rate: 2008-2002	**1.1%**	**1.2%**	**1.1%**



B.13 SYSTEM CAPACITY INFORMATION

Table B.13.1
Seasonal Firm Purchases – SUMMER
(MN Rules 7849.0280, Item B)

		Nebraska Public Power District	Mid America Energy	Minnesota Power	Dairyland	Iowa Illinois Gas and Elec.	Union Elec.	Enron Power Marketing, Inc.	Omaha Public Power District	MidAmerican Energy Corp.	Trans Alta	Central MN Municipal Power Coop	Basin Electric Power Compnay	Great River Energy	Western Area Power Administration	Manitoba 150	Manitoba 200	Total
1996	SUMMER			150	4					100						150	200	604
1997	SUMMER			150	4											150	200	504
1998	SUMMER	60		225	4			65	44	50						150	200	798
1999	SUMMER		50	175	4			30	56							150	200	665
2000	SUMMER			250				150			25					150	200	775
2001	SUMMER			85								15	50	75	2	150	200	577
2002	SUMMER												50	75	2	150	200	477
2003	SUMMER								35				50	75	2	150	200	512
2004	SUMMER												50	75	2	150	200	477
2005	SUMMER												50	75	2	150	200	477
2006	SUMMER												54	81	2	150	200	487
2007	SUMMER														2	150	200	352
2008	SUMMER														2	150	200	352
2009	SUMMER														2	150	200	352
2010	SUMMER														2	150	200	352
2011	SUMMER														2	150	200	352
2012	SUMMER														2	150	200	352
2013	SUMMER														2	150	200	352
2014	SUMMER														2	150	200	352
2015	SUMMER														2		200	202
2016	SUMMER														2		200	202
2017	SUMMER														2			2
2018	SUMMER														2			2
2019	SUMMER														2			2
2020	SUMMER														2			2
2021	SUMMER														2			2
2022	SUMMER														2			2

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.2
Seasonal Firm Purchases – WINTER
(MN Rules 7849.0280, Item B)

		Dairyland	MidAmerican Energy Corp	Minnesota Power	Manitoba Hydro	Central MN Municipal Power Agency	Basin Elec. Power Corp	Great River Energy	Western Area Power Administration	Total
1996	WINTER	4								4
1997	WINTER	4								4
1998	WINTER	4								4
1999	WINTER	4								4
2000	WINTER		200	25	50					275
2001	WINTER					11	50	75		136
2002	WINTER					12	50	75	2	139
2003	WINTER								2	2
2004	WINTER						50	75	2	127
2005	WINTER						50	75	2	127
2006	WINTER						54	75	2	131
2007	WINTER								2	2
2008	WINTER								2	2
2009	WINTER								2	2
2010	WINTER								2	2
2011	WINTER								2	2
2012	WINTER								2	2
2013	WINTER								2	2
2014	WINTER								2	2
2015	WINTER								2	2
2016	WINTER								2	2
2017	WINTER								2	2
2018	WINTER								2	2
2019	WINTER								2	2
2020	WINTER								2	2
2021	WINTER								2	2
2022	WINTER								2	2

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.3
Seasonal Firm Sales – SUMMER
(MN Rules 7849.0280, Item B)

		Wisconsin Public Service	Enron	Municipals	United Power	Wisconsin Rapids	Power Co.	Barron	Enron Power Marketing, Inc.	New Ulm	Total
1996	SUMMER	100	45	19		15	100				279
1997	SUMMER			13		15	150				178
1998	SUMMER			14		15		7			36
1999	SUMMER			16	100	15		6			137
2000	SUMMER			13		15		8	150	15	201
2001	SUMMER			15							15
2002	SUMMER			15							15
2003	SUMMER			15							15
2004	SUMMER			16							16
2005	SUMMER										0
2006	SUMMER										0
2007	SUMMER										0
2008	SUMMER										0
2009	SUMMER										0
2010	SUMMER										0
2011	SUMMER										0
2012	SUMMER										0
2013	SUMMER										0
2014	SUMMER										0
2015	SUMMER										0
2016	SUMMER										0
2017	SUMMER										0
2018	SUMMER										0
2019	SUMMER										0
2020	SUMMER										0
2021	SUMMER										0
2022	SUMMER										0

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.4
Seasonal Firm Sales – WINTER
(MN Rules 7849.0280, Item B)

		Municipals	United Power	Wisconsin Rapids	Power Co.	Central MN Municipal Power Agency	Barron	Willmar	Manitoba 150	Manitoba 200	Total
1996	WINTER	20	100						150		270
1997	WINTER	18		15	100				150	200	483
1998	WINTER	16	75	15		7		10	150	200	473
1999	WINTER	18		15			6		150	200	389
2000	WINTER	18		15			6		150	200	389
2001	WINTER	11		15			8		150	200	384
2002	WINTER	12							150	200	362
2003	WINTER	15							150	200	365
2004	WINTER	15							150	200	365
2005	WINTER	16							150	200	366
2006	WINTER	15							150	200	365
2007	WINTER								150	200	350
2008	WINTER								150	200	350
2009	WINTER								150	200	350
2010	WINTER								150	200	350
2011	WINTER								150	200	350
2012	WINTER								150	200	350
2013	WINTER								150	200	350
2014	WINTER								150	200	350
2015	WINTER								400	200	600
2016	WINTER								400		400
2017	WINTER								400		400
2018	WINTER								200		200
2019	WINTER										0
2020	WINTER										0
2021	WINTER										0
2022	WINTER										0

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.5
Seasonal Participation Purchases - SUMMER
(MN Rules 7849.0280, Item C)

		Ameren Energy Marketing Corp	Barron	Basin Electric Power Coop	Black Hills Power and Light	Calpine	Calpine Mankato	Central Iowa Power Coop	Central MN Municipal Power Agency	Constellation Commodities Group	Coyote	Cyprus	Detroit Edison
1996	SUMMER	0	4								150		
1997	SUMMER	0	4								150		
1998	SUMMER	0	4								150		
1999	SUMMER	150	4	50					5		150		
2000	SUMMER	218	4						2		150		
2001	SUMMER	148						25			150		
2002	SUMMER	235			40						100		
2003	SUMMER	255							25		100		
2004	SUMMER	235							25		100		
2005	SUMMER	0							25	100	100		
2006	SUMMER	0				20	320			62	100	40	69
2007	SUMMER	100					312			285	100	40	
2008	SUMMER						312			90	100	40	
2009	SUMMER						312			95	100	40	
2010	SUMMER						312			100	100	40	
2011	SUMMER						312				100		
2012	SUMMER						312				100		
2013	SUMMER						312				100		
2014	SUMMER						312				100		
2015	SUMMER						312				100		
2016	SUMMER						312				0		
2017	SUMMER						312				0		
2018	SUMMER						312				0		
2019	SUMMER						312				0		
2020	SUMMER						312				0		
2021	SUMMER						312				0		
2022	SUMMER						312				0		

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.5 - Continued
Seasonal Participation Purchases – SUMMER
(MN Rules 7849.0280, Item C)

		Dynegy Power Marketing	Dynegy Power Marketing	Enron Power Marketing	Exelon	Fibro Minn	Gen Sys Energy	Generic PPA	Great River Energy	Hutchinson Utilities Commission	Invenergy	Kansas City Power and Light	Laurentian	LS Power	Madelia	Manitoba Hydro	Manitoba Hydro Baseload
1996	SUMMER															750	
1997	SUMMER											50				500	
1998	SUMMER											50			8	500	
1999	SUMMER														8	725	
2000	SUMMER			100											8	675	
2001	SUMMER		100	100											8	700	
2002	SUMMER		150				20			6		25				600	
2003	SUMMER		100													760	
2004	SUMMER		100				50									960	
2005	SUMMER		158				70									700	
2006	SUMMER	108	300		125	0		0			0		0	245		713	
2007	SUMMER	108	550			50		0	160	20	0		35	245		500	
2008	SUMMER	108	150			50		0			301		35	245		713	
2009	SUMMER					50		0			301		35	245		713	
2010	SUMMER					50		136			301		35	245		500	
2011	SUMMER					50		136			301		35	245		500	
2012	SUMMER					50		136			301		35	245		500	
2013	SUMMER					50		349			301		35	245		500	
2014	SUMMER					50		485			301		35	245		500	
2015	SUMMER					50		485			301		35	245			375
2016	SUMMER					50		969			301		35	245			375
2017	SUMMER					50		1241			301		35	245			375
2018	SUMMER					50		1649			301		35	245			375
2019	SUMMER					50		1921			301		35	245			375
2020	SUMMER					50		2057			301		35	245			375
2021	SUMMER					50		2193			301		35	245			375
2022	SUMMER					50		2193			301		35	245			375

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.5 - Continued
Seasonal Participation Purchases – SUMMER
(MN Rules 7849.0280, Item C)

		MidAmerican Energy Corp	Minnesota Power	Minnkota Power Coop	Basin Municipal Power	MN Municipal Power Agency	Montana Dakota Utilties	MPEX (a division of MP)	Non-Utility Group	Indiana Public Service Co	Public Power District	Otter Tail Power	Reliant Energy Services
1996	SUMMER			150					110			75	
1997	SUMMER	50		50					328			75	
1998	SUMMER			50	10				356			75	
1999	SUMMER			50			10		360		40	75	
2000	SUMMER			50					360			75	
2001	SUMMER			20				15	365	50		75	50
2002	SUMMER	150	50	20					364			75	
2003	SUMMER	150	100	0					381		10	75	
2004	SUMMER	150	100	0					381			75	
2005	SUMMER		100	0		130			381			50	
2006	SUMMER		100	100					75				
2007	SUMMER		100	100		10			75				
2008	SUMMER			100		10			75				
2009	SUMMER			100		10			75				
2010	SUMMER			100		10			75				
2011	SUMMER			100					75				
2012	SUMMER			100					75				
2013	SUMMER			100					71				
2014	SUMMER			100					71				
2015	SUMMER			100					71				
2016	SUMMER								71				
2017	SUMMER								71				
2018	SUMMER								38				
2019	SUMMER								38				
2020	SUMMER								38				
2021	SUMMER								38				
2022	SUMMER								38				

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.5 - Continued
Seasonal Participation Purchases – SUMMER
(MN Rules 7849.0280, Item C)

		Short Term	Split Rock Energy	St. Paul	The Energy Authority	United Power Assoc	Utilicorp United	Utilicorp United	Western Resources Inc.	Wind	Wisconsin Electric Power	Wisconsin Public Service	**Total**
1996	SUMMER					50						50	1339
1997	SUMMER					50							1257
1998	SUMMER					50					120		1373
1999	SUMMER					50		35	100			73	1885
2000	SUMMER					50			50				1742
2001	SUMMER					50	100		83				2039
2002	SUMMER		50		30	50	50	10					2025
2003	SUMMER				20	50			61				2087
2004	SUMMER		100			50							2326
2005	SUMMER					50						200	2064
2006	SUMMER	0	200	25		50				61		50	2763
2007	SUMMER	0		25		50				76			2941
2008	SUMMER	642		25		50				76			3122
2009	SUMMER	750		25		50				96			2997
2010	SUMMER	750		25						96			2875
2011	SUMMER	750		25						98			2727
2012	SUMMER	750		25						99			2728
2013	SUMMER	750		25						100			2938
2014	SUMMER	750		25						101			3075
2015	SUMMER	750		25						102			2951
2016	SUMMER	750		25						102			3235
2017	SUMMER	750		25						102			3507
2018	SUMMER	750		25						102			3882
2019	SUMMER	750		25						101			4153
2020	SUMMER	750		25						101			4289
2021	SUMMER	750		25						101			4425
2022	SUMMER	750		25						101			4425

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.6
Seasonal Participation Purchases - WINTER
(MN Rules 7849.0280, Item C)

		American Energy Marketing Corp	Barron	Calpine Mankato	Central MN Municipal Power Agency	Cyprus	Dynegy Power Marketing	Fibro Minn	Generic PPA	Gen Sys Energy	Invenergy	Laurentian	LS Power	Madelia	Manitoba Hydro
1996	WINTER														500
1997	WINTER														500
1998	WINTER														500
1999	WINTER		4												500
2000	WINTER		4											8	500
2001	WINTER	100	4		2		100							8	500
2002	WINTER		4				100								500
2003	WINTER		4		25		100								500
2004	WINTER				25										500
2005	WINTER				25					50					500
2006	WINTER			262	31	40				50	0	0	262		500
2007	WINTER			262		40	108	50			0	35	262		713
2008	WINTER			262		40		50			357	35	262		713
2009	WINTER			262		40		50			357	35	262		500
2010	WINTER			262		40		50	160		357	35	262		500
2011	WINTER			262				50	160		357	35	262		500
2012	WINTER			262				50	160		357	35	262		500
2013	WINTER			262				50	410		357	35	262		500
2014	WINTER			262				50	570		357	35	262		500
2015	WINTER			262				50	570		357	35	262		
2016	WINTER			262				50	1140		357	35	262		
2017	WINTER			262				50	1460		357	35	262		
2018	WINTER			262				50	1940		357	35	262		
2019	WINTER			262				50	2260		357	35	262		
2020	WINTER			262				50	2420		357	35	262		
2021	WINTER			262				50	2580		357	35	262		
2022	WINTER			262				50	2580		357	35	262		

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.6 - Continued
Seasonal Participation Purchases – WINTER
(MN Rules 7849.0280, Item C)

		Manitoba Hydro Baseload	MidAmerican Energy Corp	Minnesota Power	Minnkota Power Coop	Non-Utility Group	St. Paul	Western Resources Inc.	Wind	Wisconsin Public Service	**Total**
1996	WINTER					98				150	748
1997	WINTER					111				150	761
1998	WINTER					374				150	1,024
1999	WINTER					375					879
2000	WINTER					377					889
2001	WINTER					377					1,091
2002	WINTER			50		373		61			1,088
2003	WINTER		50		20	377					1,076
2004	WINTER			100		398					1,023
2005	WINTER			100		398					1,073
2006	WINTER			100		75	25		145	87	1,577
2007	WINTER			100		75	25		148		1,818
2008	WINTER					75	25		152		1,971
2009	WINTER					75	25		152		1,758
2010	WINTER					75	25		173		1,939
2011	WINTER					75	25		184		1,910
2012	WINTER					75	25		206		1,931
2013	WINTER					71	25		216		2,188
2014	WINTER					71	25		227		2,360
2015	WINTER	375				71	25		227		2,235
2016	WINTER	375				71	25		227		2,805
2017	WINTER	375				71	25		225		3,123
2018	WINTER	375				38	25		219		3,563
2019	WINTER	375				38	25		219		3,882
2020	WINTER	375				38	25		219		4,042
2021	WINTER	375				38	25		219		4,203
2022	WINTER	375				38	25		219		4,203

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.7
Seasonal Participation Sales – SUMMER
(MN Rules 7849.0280, Item C)

		Constellation Comm. Group	Gensys Energy	Great River Energy	Melrose	Montana Dakota Util	Montana Dakota Util	Omaha Public Power District	Otter Tail Power	Wisc Power Assoc	Wisconsin Electric Power Corp	Wisconsin Public Service	**Total**
1996	SUMMER									150			150
1997	SUMMER												0
1998	SUMMER				3					126	250		379
1999	SUMMER				3			50			250	176	479
2000	SUMMER				3				50			186	239
2001	SUMMER				3							200	203
2002	SUMMER											200	200
2003	SUMMER												0
2004	SUMMER												0
2005	SUMMER											200	200
2006	SUMMER			50					32				82
2007	SUMMER	100	50	100		85	10						345
2008	SUMMER			150		90	10						250
2009	SUMMER					95	10						105
2010	SUMMER					100	10						110
2011	SUMMER												0
2012	SUMMER												0
2013	SUMMER												0
2014	SUMMER												0
2015	SUMMER												0
2016	SUMMER												0
2017	SUMMER												0
2018	SUMMER												0
2019	SUMMER												0
2020	SUMMER												0
2021	SUMMER												0
2022	SUMMER												0

B.13 SYSTEM CAPAC0ITY INFORMATION - Continued

Table B.13.8
Seasonal Participation Sales – WINTER
(MN Rules 7849.0280, Item C)

		Melrose	Minnkota Power	Municipals	Otter Tail Power	United Power Assoc	Wisc Power Assoc	Wisconsin Electric Power Corp	**Total**
1996	WINTER		50		75	50	150		325
1997	WINTER		50		75	50	150		325
1998	WINTER	3	50		75	50	150		328
1999	WINTER	3	50		75	50	150		328
2000	WINTER	3	50		75	50		150	328
2001	WINTER	3	50		75	50			178
2002	WINTER			10	75	50			135
2003	WINTER				75	50			125
2004	WINTER	3			75	50			128
2005	WINTER	3				50			53
2006	WINTER					50			50
2007	WINTER					50			50
2008	WINTER					50			50
2009	WINTER					50			50
2010	WINTER								0
2011	WINTER								0
2012	WINTER								0
2013	WINTER								0
2014	WINTER								0
2015	WINTER								0
2016	WINTER								0
2017	WINTER								0
2018	WINTER								0
2019	WINTER								0
2020	WINTER								0
2021	WINTER								0
2022	WINTER								0

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.9
Load and Generating Capacity Data Excluding Plants Needing a CON - SUMMER
(MN Rules 7849.0280, Item D)

	Seasonal System Demand	Annual System Demand	Total Seasonal Firm Purchases	Total Seasonal Firm Sales	Seasonal Adjusted Net Demand	Annual Adjusted Net Demand	Net Generating Capacity	Total Participation Purchases	Total Participation Sales	Adjusted Net Capability	Net Reserve Capacity Obligation	Total Firm Capactiy Obligation	Surplus or Deficit Capacity
1996	7488	7488	604	279	7163	7163	7110	1339	150	8299	1074	8237	62
1997	7353	7353	504	178	7027	7027	7118	1257	0	8375	1054	8081	294
1998	7659	7659	798	36	6897	6897	7150	1373	379	8144	1035	7932	212
1999	7990	7990	665	137	7462	7462	7187	1885	479	8593	1119	8581	12
2000	7936	7936	775	201	7362	7362	7243	1742	239	8746	1104	8466	280
2001	8349	8349	577	15	7787	7787	7153	2039	203	8988	1168	8955	34
2002	8239	8239	477	15	7777	7777	7275	2025	200	9100	1167	8943	157
2003	8281	8281	512	15	7784	7784	7226	2087	0	9313	1168	8951	362
2004	8596	8596	477	16	8135	8135	7229	2326	0	9555	1220	9355	200
2005	8501	8501	477	0	8024	8024	7732	2064	200	9596	1204	9227	369
2006	9034	9034	487	0	8547	8547	7627	2763	82	10308	1282	9829	479
2007	9427	9427	352	0	9075	9075	7577	2941	345	10172	1361	10436	-264
2008	10302	10302	352	0	9950	9950	7432	3122	250	10304	1493	11443	-1139
2009	10446	10446	352	0	10094	10094	7970	2997	105	10862	1514	11608	-746
2010	10630	10630	352	0	10278	10278	8033	2875	110	10798	1542	11819	-1021
2011	10773	10773	352	0	10421	10421	8085	2727	0	10812	1563	11984	-1172
2012	10893	10893	352	0	10541	10541	8097	2728	0	10825	1581	12122	-1297
2013	11006	11006	352	0	10654	10654	8097	2938	0	11035	1598	12252	-1217
2014	11143	11143	352	0	10791	10791	8097	3075	0	11172	1619	12410	-1238
2015	11250	11250	202	0	11048	11048	8097	2951	0	11048	1657	12705	-1658
2016	11382	11382	202	0	11180	11180	8097	3235	0	11332	1677	12857	-1525
2017	11487	11487	2	0	11484	11484	8097	3507	0	11604	1723	13207	-1603
2018	11619	11619	2	0	11617	11617	8097	3882	0	11979	1743	13359	-1381
2019	11732	11732	2	0	11730	11730	8097	4153	0	12250	1760	13490	-1240
2020	11860	11860	2	0	11858	11858	8097	4289	0	12386	1779	13636	-1251
2021	11961	11961	2	0	11959	11959	8097	4425	0	12522	1794	13753	-1232
2022	12105	12105	2	0	12103	12103	8097	4425	0	12522	1815	13919	-1397

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.9
Load and Generating Capacity Data Excluding Plants Needing a CON – SUMMER - Continued
(MN Rules 7849.0280, Item D)

NOTES :

1. Forecasted demand values based on a 90% forecast level with DSM Adjustment.
2. Summer and winter seasons as defined by MAPP : Summer is May - October, Winter is the following November – April
3. Wind resources are included in net generating capacity at nameplate capacity. New wind resources are projected to be accredited at 13.5% nameplate capacity. Actual winter accreditation is likely to be higher.

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.10
Load and Generating Capacity Data Excluding Plants Needing a CON - WINTER
(MN Rules 7849.0280, Item D)

	Seasonal System Demand	Annual System Demand	Total Seasonal Firm Purchases	Total Seasonal Firm Sales	Seasonal Adjusted Net Demand	Annual Adjusted Net Demand	Net Generating Capacity	Total Participation Purchases	Total Participation Sales	Adjusted Net Capability	Net Reserve Capacity Obligation	Total Firm Capactiy Obligation	Surplus or Deficit Capacity
1996	6081	7488	4	270	6347	7754	7253	748	325	7676	1163	7510	166
1997	5869	7353	4	483	6348	7832	7367	761	325	7803	1175	7523	280
1998	5877	7659	4	473	6346	8128	7406	1024	328	8102	1219	7565	537
1999	6187	7990	4	389	6572	8375	7482	879	328	8033	1256	7828	205
2000	6422	7936	275	389	6536	8050	7537	889	328	8098	1208	7744	354
2001	6557	8349	136	384	6805	8597	7534	1091	178	8446	1290	8095	352
2002	6221	8239	139	362	6444	8462	7491	1088	135	8444	1269	7713	731
2003	6386	8281	2	365	6749	8644	7738	1076	125	8689	1297	8045	643
2004	6653	8596	127	365	6891	8834	7718	1023	128	8613	1325	8216	397
2005	6873	8501	127	366	7112	8740	7718	1073	53	8738	1311	8423	315
2006	6833	9034	131	365	7067	9268	7936	1577	50	9463	1390	8457	1006
2007	7413	9427	2	350	7760	9775	7616	1818	50	9384	1466	9227	157
2008	7509	10302	2	350	7856	10650	7895	1971	50	9815	1598	9454	361
2009	7575	10446	2	350	7923	10793	8401	1758	50	10108	1619	9542	566
2010	7646	10630	2	350	7994	10977	8464	1939	0	10403	1647	9640	763
2011	7664	10773	2	350	8011	11120	8516	1910	0	10426	1668	9679	747
2012	7676	10893	2	350	8024	11241	8528	1931	0	10460	1686	9710	750
2013	7712	11006	2	350	8060	11354	8528	2188	0	10717	1703	9763	954
2014	7721	11143	2	350	8069	11491	8528	2360	0	10888	1724	9792	1096
2015	7743	11250	2	600	8340	11848	8528	2235	0	10763	1777	10118	645
2016	7747	11382	2	400	8145	11780	8528	2805	0	11333	1767	9912	1421
2017	7777	11487	2	400	8175	11884	8528	3123	0	11651	1783	9957	1694
2018	7790	11619	2	200	7988	11817	8528	3563	0	12091	1772	9760	2330
2019	7815	11732	2	0	7813	11730	8528	3882	0	12411	1760	9572	2838
2020	7810	11860	2	0	7808	11858	8528	4042	0	12571	1779	9587	2984
2021	7839	11961	2	0	7837	11959	8528	4203	0	12731	1794	9631	3100
2022	7853	12105	2	0	7851	12103	8528	4203	0	12731	1816	9667	3064

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.10 - Continued

Load and Generating Capacity Data Excluding Plants Needing a CON - WINTER (MN Rules 7849.0280, Item D)

NOTES :
1. Forecasted demand values based on a 90% forecast level with a DSM Adjustment.
2. Summer and winter seasons as defined by MAPP : Summer is May - October, Winter is the following November - April
3. Wind resources are included in net generating capacity at nameplate capacity. New wind resources are projected to be accredited at 13.5% nameplate capacity. Actual winter accreditation is likely to be higher.

B.13 SYSTEM CAPACITY INFORMATION – Continued

Table B.13.11
Load and Generating Capacity Data Including Plants Needing a CON - SUMMER
(MN Rules 7849.0280, Item E)

	Seasonal System Demand	Annual System Demand	Total Seasonal Firm Purchases	Total Seasonal Firm Sales	Seasonal Adjusted Net Demand	Annual Adjusted Net Demand	Net Generating Capacity	Total Participation Purchases	Total Participation Sales	Adjusted Net Capability	Net Reserve Capacity Obligation	Total Firm Capactiy Obligation	Surplus or Deficit Capacity
1996	7488	7488	604	279	7163	7163	7110	1339	150	8299	1074	8237	62
1997	7353	7353	504	178	7027	7027	7118	1257	0	8375	1054	8081	294
1998	7659	7659	798	36	6897	6897	7150	1373	379	8144	1035	7932	212
1999	7990	7990	665	137	7462	7462	7187	1885	479	8593	1119	8581	12
2000	7936	7936	775	201	7362	7362	7243	1742	239	8746	1104	8466	280
2001	8349	8349	577	15	7787	7787	7153	2039	203	8988	1168	8955	34
2002	8239	8239	477	15	7777	7777	7275	2025	200	9100	1167	8943	157
2003	8281	8281	512	15	7784	7784	7226	2087	0	9313	1168	8951	362
2004	8596	8596	477	16	8135	8135	7229	2326	0	9555	1220	9355	200
2005	8501	8501	477	0	8024	8024	7732	2064	200	9596	1204	9227	369
2006	9034	9034	487	0	8547	8547	7627	2763	82	10308	1282	9829	479
2007	9427	9427	352	0	9075	9075	7577	2941	345	10172	1361	10436	-264
2008	10302	10302	352	0	9950	9950	7432	3122	250	10304	1493	11443	-1139
2009	10446	10446	352	0	10094	10094	7985	2997	105	10877	1514	11608	-731
2010	10630	10630	352	0	10278	10278	8048	2875	110	10813	1542	11819	-1006
2011	10773	10773	352	0	10421	10421	8156	2727	0	10883	1563	11984	-1101
2012	10893	10893	352	0	10541	10541	8250	2728	0	10978	1581	12122	-1145
2013	11006	11006	352	0	10654	10654	8249	2938	0	11187	1598	12252	-1065
2014	11143	11143	352	0	10791	10791	8331	3075	0	11406	1619	12410	-1004
2015	11250	11250	202	0	11048	11048	8331	2951	0	11282	1657	12705	-1423
2016	11382	11382	202	0	11180	11180	8331	3235	0	11567	1677	12857	-1290
2017	11487	11487	2	0	11484	11484	8331	3507	0	11839	1723	13207	-1368
2018	11619	11619	2	0	11617	11617	8331	3882	0	12213	1743	13359	-1146
2019	11732	11732	2	0	11730	11730	8331	4153	0	12484	1760	13490	-1005
2020	11860	11860	2	0	11858	11858	8331	4289	0	12620	1779	13636	-1016
2021	11961	11961	2	0	11959	11959	8331	4425	0	12756	1794	13753	-997
2022	12105	12105	2	0	12103	12103	8331	4425	0	12756	1815	13919	-1163

B.13 SYSTEM CAPACITY INFORMATION – Continued

Table B.13.11 - Continued

Load and Generating Capacity Data Including Plants Needing a CON - SUMMER (MN Rules 7849.0280, Item E)

NOTES :
1. Forecasted demand values based on a 90% forecast level with a DSM Adjustment.
2. Summer and winter seasons as defined by MAPP : Summer is May - October, Winter is the following November - April
3. Wind resources are included in net generating capacity at nameplate capacity. New wind resources are projected to be accredited at 13.5% nameplate capacity.
4. Prairie Island Nuclear Generating Plant [of 164 MW added to net generating capacity].

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.12
Load and Generating Capacity Data Including Plants Needing a CON - WINTER
(MN Rules 7849.0280, Item E)

	Seasonal System Demand	Annual System Demand	Total Seasonal Firm Purchases	Total Seasonal Firm Sales	Seasonal Adjusted Net Demand	Annual Adjusted Net Demand	Net Generating Capacity	Total Participation Purchases	Total Participation Sales	Adjusted Net Capability	Net Reserve Capacity Obligation	Total Firm Capactiy Obligation	Surplus or Deficit Capacity
1996	6081	7488	4	270	6347	7754	7253	748	325	7676	1163	7510	166
1997	5869	7353	4	483	6348	7832	7367	761	325	7803	1175	7523	280
1998	5877	7659	4	473	6346	8128	7406	1024	328	8102	1219	7565	537
1999	6187	7990	4	389	6572	8375	7482	879	328	8033	1256	7828	205
2000	6422	7936	275	389	6536	8050	7537	889	328	8098	1208	7744	354
2001	6557	8349	136	384	6805	8597	7534	1091	178	8446	1290	8095	352
2002	6221	8239	139	362	6444	8462	7491	1088	135	8444	1269	7713	731
2003	6386	8281	2	365	6749	8644	7738	1076	125	8689	1297	8045	643
2004	6653	8596	127	365	6891	8834	7718	1023	128	8613	1325	8216	397
2005	6873	8501	127	366	7112	8740	7718	1073	53	8738	1311	8423	315
2006	6833	9034	131	365	7067	9268	7936	1577	50	9463	1390	8457	1006
2007	7413	9427	2	350	7760	9775	7616	1818	50	9384	1466	9227	157
2008	7509	10302	2	350	7856	10650	7895	1971	50	9815	1598	9454	361
2009	7575	10446	2	350	7923	10793	8401	1758	50	10108	1619	9542	566
2010	7646	10630	2	350	7994	10977	8464	1939	0	10403	1647	9640	763
2011	7664	10773	2	350	8011	11120	8599	1910	0	10426	1668	9679	747
2012	7676	10893	2	350	8024	11241	8610	1931	0	10542	1686	9710	832
2013	7712	11006	2	350	8060	11354	8610	2188	0	10799	1703	9763	1036
2014	7721	11143	2	350	8069	11491	8692	2360	0	11052	1724	9792	1260
2015	7743	11250	2	600	8340	11848	8692	2235	0	10927	1777	10118	809
2016	7747	11382	2	400	8145	11780	8692	2805	0	11497	1767	9912	1585
2017	7777	11487	2	400	8175	11884	8692	3123	0	11815	1783	9957	1858
2018	7790	11619	2	200	7988	11817	8692	3563	0	12255	1772	9760	2494
2019	7815	11732	2	0	7813	11730	8692	3882	0	12575	1760	9572	3002
2020	7810	11860	2	0	7808	11858	8692	4042	0	12735	1779	9587	3148
2021	7839	11961	2	0	7837	11959	8692	4203	0	12895	1794	9631	3264
2022	7853	12105	2	0	7851	12103	8692	4203	0	12895	1816	9667	3228

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.12 - Continued

Load and Generating Capacity Data Including Plants Needing a CON - WINTER (MN Rules 7849.0280, Item E)

NOTES :
1. Forecasted demand values based on a 90% forecast level with a DSM Adjustment.
2. Summer and winter seasons as defined by MAPP : Summer is May - October, Winter is the following November - April
3. Wind resources are included in net generating capacity at nameplate capacity. New wind resources are projected to be accredited at 13.5% nameplate capacity. Actual winter accreditation is likely to be higher.
4. Prairie Island Nuclear Generating Plant [164 MW added to net generating capacity].

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.13
Load and Generating Capacity Data Including Future Plants Needing a CON - SUMMER
(MN Rules 7849.0280, Item F)

	Seasonal System Demand	Annual System Demand	Total Seasonal Firm Purchases	Total Seasonal Firm Sales	Seasonal Adjusted Net Demand	Annual Adjusted Net Demand	Net Generating Capacity	Total Participation Purchases	Total Participation Sales	Adjusted Net Capability	Net Reserve Capacity Obligation	Total Firm Capactiy Obligation	Surplus or Deficit Capacity
1996	7488	7488	604	279	7163	7163	7110	1339	150	8299	1074	8237	62
1997	7353	7353	504	178	7027	7027	7118	1257	0	8375	1054	8081	294
1998	7659	7659	798	36	6897	6897	7150	1373	379	8144	1035	7932	212
1999	7990	7990	665	137	7462	7462	7187	1885	479	8593	1119	8581	12
2000	7936	7936	775	201	7362	7362	7243	1742	239	8746	1104	8466	280
2001	8349	8349	577	15	7787	7787	7153	2039	203	8988	1168	8955	34
2002	8239	8239	477	15	7777	7777	7275	2025	200	9100	1167	8943	157
2003	8281	8281	512	15	7784	7784	7226	2087	0	9313	1168	8951	362
2004	8596	8596	477	16	8135	8135	7229	2326	0	9555	1220	9355	200
2005	8501	8501	477	0	8024	8024	7732	2064	200	9596	1204	9227	369
2006	9034	9034	487	0	8547	8547	7627	2763	82	10308	1282	9829	479
2007	9427	9427	352	0	9075	9075	7577	2941	345	10172	1361	10436	-264
2008	10302	10302	352	0	9950	9950	7432	3122	250	10304	1493	11443	-1139
2009	10446	10446	352	0	10094	10094	7984	2997	105	10877	1514	11608	-731
2010	10630	10630	352	0	10278	10278	8048	2875	110	10813	1542	11819	-1006
2011	10773	10773	352	0	10421	10421	8156	2727	0	10883	1563	11984	-1101
2012	10893	10893	352	0	10541	10541	8168	2728	0	10896	1581	12122	-1227
2013	11006	11006	352	0	10654	10654	8250	2938	0	11188	1598	12252	-1064
2014	11143	11143	352	0	10791	10791	8250	3075	0	11325	1619	12410	-1085
2015	11250	11250	202	0	11048	11048	8337	2951	0	11288	1657	12705	-1417
2016	11382	11382	202	0	11180	11180	8337	3235	0	11573	1677	12857	-1285
2017	11487	11487	2	0	11484	11484	8337	3507	0	11845	1723	13207	-1363
2018	11619	11619	2	0	11617	11617	8337	3882	0	12219	1743	13359	-1140
2019	11732	11732	2	0	11730	11730	8337	4153	0	12490	1760	13490	-1000
2020	11860	11860	2	0	11858	11858	8337	4289	0	12626	1779	13636	-1010
2021	11961	11961	2	0	11959	11959	8337	4425	0	12762	1794	13753	-991
2022	12105	12105	2	0	12103	12103	8337	4425	0	12762	1815	13919	-1157

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.13 - Continued

Load and Generating Capacity Data Including Future Plants Needing a CON - SUMMER (MN Rules 7849.0280, Item F)

NOTES :
1. Forecasted demand values based on a 90% forecast level with a DSM Adjustment.
2. Summer and winter seasons as defined by MAPP : Summer is May - October, Winter is the following November - April
3. Wind resources are included in net generating capacity at nameplate capacity. The only new wind resource is our 100 MW Grand Meadow facility which is included at nameplate as it is not accredited yet.
Future wind resources were not included because at this point we have not determined the ownership versus PPA split. Xcel continues to project accredited wind resources at 13.5% nameplate capacity.
4. The future Manitoba Hydro purchase that begins in 2015 is included here. This resource does not technically need a CON, however, as part of the Track Two process it wil be subjected to the "CON-like" review process.
Xcel Energy has issued an RFP for a 160 MW of Summer peaking to be available by 2011. We are still in the selection process and no term sheet has been signed to date.
Since this will result in a Summer only PPA a CON is not required.
5. Xcel Energy will need additional resources in future years, the specific details will be addressed in future resource plans.

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.14
Load and Generating Capacity Data Including Future Plants Needing a CON - WINTER
(MN Rules 7849.0280, Item F)

	Seasonal System Demand	Annual System Demand	Total Seasonal Firm Purchases	Total Seasonal Firm Sales	Seasonal Adjusted Net Demand	Annual Adjusted Net Demand	Net Generating Capacity	Total Participation Purchases	Total Participation Sales	Adjusted Net Capability	Net Reserve Capacity Obligation	Total Firm Capactiy Obligation	Surplus or Deficit Capacity
1996	6081	7488	4	270	6347	7754	7253	748	325	7676	1163	7510	166
1997	5869	7353	4	483	6348	7832	7367	761	325	7803	1175	7523	280
1998	5877	7659	4	473	6346	8128	7406	1024	328	8102	1219	7565	537
1999	6187	7990	4	389	6572	8375	7482	879	328	8033	1256	7828	205
2000	6422	7936	275	389	6536	8050	7537	889	328	8098	1208	7744	354
2001	6557	8349	136	384	6805	8597	7534	1091	178	8446	1290	8095	352
2002	6221	8239	139	362	6444	8462	7491	1088	135	8444	1269	7713	731
2003	6386	8281	2	365	6749	8644	7738	1076	125	8689	1297	8045	643
2004	6653	8596	127	365	6891	8834	7718	1023	128	8613	1325	8216	397
2005	6873	8501	127	366	7112	8740	7718	1073	53	8738	1311	8423	315
2006	6833	9034	131	365	7067	9268	7936	1577	50	9463	1390	8457	1006
2007	7413	9427	2	350	7760	9775	7616	1818	50	9384	1466	9227	157
2008	7509	10302	2	350	7856	10650	7895	1971	50	9815	1598	9454	361
2009	7575	10446	2	350	7923	10793	8401	1758	50	10108	1619	9542	566
2010	7646	10630	2	350	7994	10977	8464	1939	0	10403	1647	9640	763
2011	7664	10773	2	350	8011	11120	8516	1910	0	10426	1668	9679	747
2012	7676	10893	2	350	8024	11241	8528	1931	0	10460	1686	9710	750
2013	7712	11006	2	350	8060	11354	8528	2188	0	10717	1703	9763	954
2014	7721	11143	2	350	8069	11491	8528	2360	0	10888	1724	9792	1096
2015	7743	11250	2	600	8340	11848	8528	2235	0	10763	1777	10118	645
2016	7747	11382	2	400	8145	11780	8528	2805	0	11333	1767	9912	1421
2017	7777	11487	2	400	8175	11884	8528	3123	0	11651	1783	9957	1694
2018	7790	11619	2	200	7988	11817	8528	3563	0	12091	1772	9760	2330
2019	7815	11732	2	0	7813	11730	8528	3882	0	12411	1760	9572	2838
2020	7810	11860	2	0	7808	11858	8528	4042	0	12571	1779	9587	2984
2021	7839	11961	2	0	7837	11959	8528	4203	0	12731	1794	9631	3100
2022	7853	12105	2	0	7851	12103	8528	4203	0	12731	1816	9667	3064

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.14 - Continued

Load and Generating Capacity Data Including Future Plants Needing a CON - WINTER (MN Rules 7849.0280, Item F)

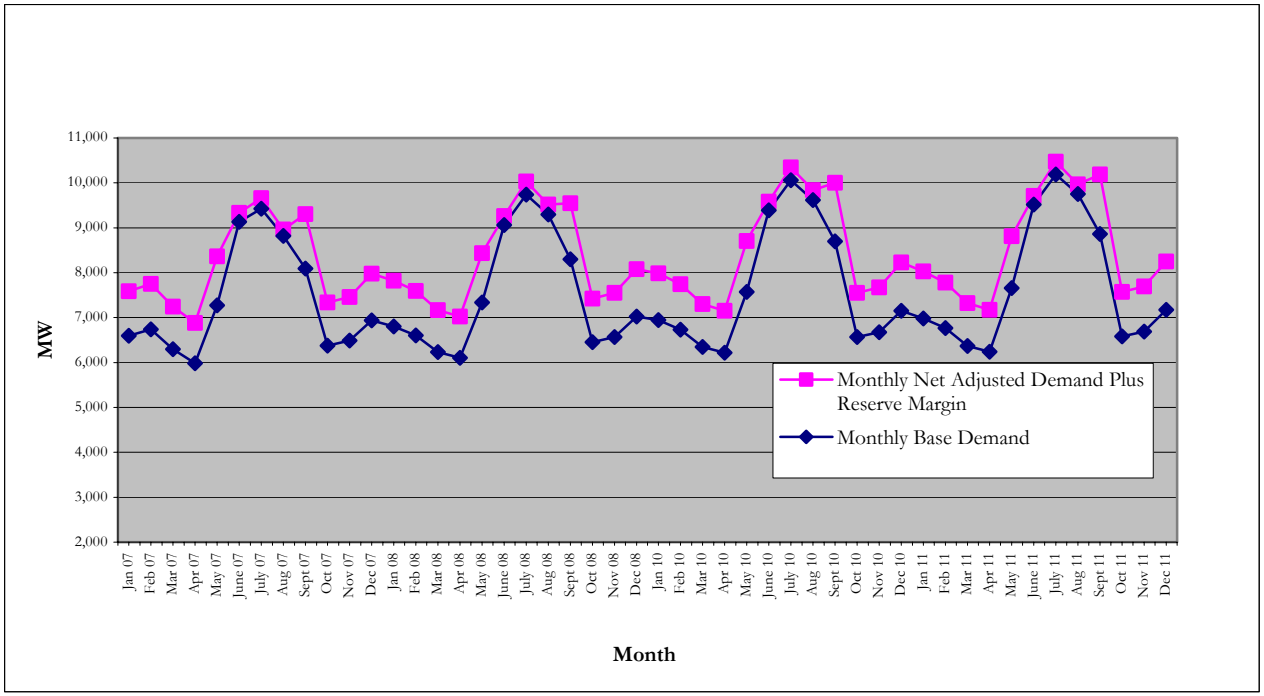
NOTES :
1. Forecasted demand values based on a 90% forecast level with a DSM Adjustment.
2. Summer and winter seasons as defined by MAPP : Summer is May - October, Winter is the following November - April
3. Wind resources are included in net generating capacity at nameplate capacity. The only new wind resource is our 100 MW Grand Meadow facility, which is included at nameplate as it is not accredited yet.
Future wind resources were not included because at this point we have not determined the ownership versus PPA split. Xcel continues to project accredited wind resources at 13.5% nameplate capacity.
4. The future Manitoba Hydro purchase that begins in 2015 is included here. This resource does not technically need a CON, however, as part of the Track Two process it will be subjected to the "CON-like" review process.
5. Xcel Energy will need additional resources in future years, the specific details will be addressed in future resource plans.

B.13 SYSTEM CAPACITY INFORMATION - Continued

Table B.13.15
Proposed Additions and Retirements
(Minnesota Rules 7849.0280, Item G)

	Year	Proposed Additions (MW)	Probable Date of CON Application	Proposed Retirements (MW)	Comments
Projected	2007		Not required	274	High Bridge Coal Retirement
	2008	615	GM Portion only 2007	387	High Bridge CC Addition, Grand Meadow Wind Addition and Riverside Coal Retirement
	2009	454	Not required for Riverside; 2008 for Monticello		Riverside Combined Cycle 439 MW and Monticello 15 MW
	2010				
	2011	56	2008		Monticello uprate 56 MW
	2012	40	Not required		Sherco Upgrades
	2013	122	Not required for Sherco; 2007 for PI		Sherco Upgrades 40 MW and Prairie Island 82 MW
	2014				
	2015	82	2008		Prairie Island uprate 82 MW
	2016				
	2017				
	2018				
	2019				
	2020				
	2021				
	Total	**1,369**		**661**	

Table B.13.16
Monthly Demand and Capability
(Minnesota Rules 7849.0280, Item H)



The Monthly Net Adjusted Demand includes a 1.1% DSM Adjustment, a Load Relief Adjustment, and a 15% Reserve Margin Adjustment.

For the forecasted years, Load Relief is forecasted for June, July and August only.

The Monthly Base Demand includes a 1.1% DSM Adjustment, but no Load Relief and no Reserve Margin.

Appendix C: Demand-Side Management Programs

This Appendix contains the information required in Minn. R. Part 7849.0290 related to demand-side management ("DSM") (conservation and load management) programs.

C.1 Who is Responsible for DSM?

Fred Stoffel, Vice President of Marketing in the Utilities Group, is responsible for Xcel Energy's demand-side management programs in Minnesota, Wisconsin, Colorado, New Mexico, Texas, North Dakota, and South Dakota.

C.2 DSM Goals and Objectives

C.2.1 Current Conservation Goals, 2007-2009

Xcel Energy files a comprehensive conservation plan every three years, which includes proposed budgets and savings goals for the Company's conservation programs. On November 29, 2006, the Department of Commerce (DOC) approved our 2007/2008/2009 CIP Triennial Plan, including the proposed savings goals shown in Table C-1 (Docket No. E,G002/CIP-06-80). DOC staff evaluates energy and demand savings goals by comparing the goals with our Commission-approved integrated Resource Plan goals and historic CIP achievements.

Table C-1
DSM Goals as Approved by the Department in the 2007/2008/2009 CIP Triennial Plan

	2007	2008	2009	Total
Budget	$45,504,799	$47,002,224	$48,350,183	$140,857,206
Generator KW	87,300	90,980	92,809	271,089
Generator kWh	238,213,749	259,635,189	264,114,597	761,963,535

C.2.1.1 The Next Generation Energy Act of 2007

The Next Generation Energy Act of 2007 ("Act") represents a fundamental change in the statutory structure for DSM in Minnesota. The Act sets an aggressive state policy to significantly increase DSM in our energy portfolio and shifts the focus from historical spending to a percentage savings of retail sales. The Act seeks to achieve an annual statewide energy conservation goal of 1.5 percent of retail sales to be achieved through both direct and indirect energy conservation programs. Direct programs are traditional, customer-based Conservation Improvement Programs (CIP). Indirect programs are savings from electric utility infrastructure improvements and waste heat recovery, energy codes, appliance standards, and "market transformation" programs directed at changing consumer behavior and creating lasting market effects. For Xcel Energy, a 1.5 percent savings of retail sales is an effective doubling of the savings set forth in the 2004 Resource Plan.

The statute sets forth that a utility may request that the Commissioner reduce the energy savings required from Conservation Improvement Plans from the 1.5 percent level to a minimum of 1.0 percent of annual retail sales based on certain factors. These factors include historical conservation investment experience, customer class makeup, load growth, a conservation potential study or "other factors the commissioner determines warrants an adjustment." We considered these factors and constraints when determining an achievable goal that will deliver reliable energy savings to help meet the resource needs outlined in our 2007 Resource Plan, filed December 14, 2007.

C.2.1.2 2007 Resource Plan

For our Resource Plan, we proposed a direct energy savings goal equal to 1.1 percent of annual retail sales, assuming a graduated transition to higher DSM goals. Our proposed DSM goal for direct DSM programs will result in over 5,100 GWhs of energy savings and over 1,700 MWs of demand reductions during the 2008 through 2022 planning period. This goal represents a 30 percent increase in energy savings and a 48 percent increase in demand savings over the levels approved by the Commission in our 2004 Resource Plan. This goal is also approximately 35 percent higher than the average GWh savings goals approved in our current CIP Triennial. For perspective, our approved goals in the current CIP Triennial represent approximately 0.8 percent reduction of annual retail sales. Though ambitious, we believe the proposed 1.1 percent goal

is achievable, and as a result, we have included this level of energy conservation in the sales forecast and our modeling scenarios.

For comparison purposes, Table C-2 shows our current goals from the 2004 Resource Plan, as Ordered in Docket No E-002-/RP-04-1752, and our proposed 1.1 percent goal for the period 2005 through 2022.

Table C-2
Demand and Energy Goals

Year	2005-2019 Plan	2005-2019 Plan	1.1 percent Scenario	1.1 percent Scenario	1.1 percent Scenario
	Approved Demand Goal MW	Approved Energy Goal GWh	Demand Goal MW	Energy Goal GWh	Proposed Budget
2005	77	266			
2006	79	231			
2007	116	330			
2008	93	294	91	260	$ 47,002,224
2009	84	276	93	264	$ 48,350,183
2010	72	264	119	328	$ 91,535,420
2011	65	251	123	333	$ 95,216,191
2012	69	252	119	338	$ 98,944,600
2013	68	248	118	343	$ 102,656,754
2014	72	253	111	347	$ 106,362,703
2015	73	254	98	351	$ 110,115,550
2016	74	254	104	355	$ 113,957,721
2017	73	256	109	359	$ 117,955,764
2018	72	254	114	363	$ 122,121,965
2019	70	251	116	367	$ 126,482,964
2020			131	372	$ 131,009,189
2021			132	376	$ 135,700,102
2022			134	380	$ 140,550,584
2005-2019 Total	**1,157**	**3,934**			
Avg Annual 2005-2019	**77**	**262**			
2008-2022 Total			**1,711**	**5,136**	

Year	2005-2019 Plan	2005-2019 Plan	1.1 percent Scenario	1.1 percent Scenario	1.1 percent Scenario
	Approved Demand Goal MW	Approved Energy Goal GWh	Demand Goal MW	Energy Goal GWh	Proposed Budget
Avg Annual 2008-2022			114	342	

We have based our goals on information from our current and updated Minnesota DSM Potential Study and historical experience and performance. Our goal through direct DSM programs is a "stretch" plan representing the limits of what our conservation potential study concludes is achievable. Other considerations include internal and external analysis on how our programs can be enhanced and expanded to overcome existing barriers, as well as constraints introduced by the legislation, such as new measurement and verification requirements, changes to codes and standards, and cost effectiveness.

C.2.1.3 2010/2011/2012 Conservation Improvement Plan

The Company's next conservation plan will be filed June 1, 2009, covering the years 2010 through 2012. The plan will reflect the new energy savings goals and provisions of the Next Generation Energy Act of 2007, as well as the goals outlined in the 2007 Resource Plan.

We are currently developing a growth plan to help us meet Minnesota's new energy efficiency requirements. At this stage, we are still working to develop and complete this plan, but we expect most of the energy savings will build upon our most successful business programs such as Cooling, Motors, Lighting and programs that are process driven or more customer service oriented. Our DSM group is currently analyzing every existing program for gaps and opportunities for growth, as well as reviewing new and emerging technologies that may be on the planning horizon, such as certain solar or LED applications. We have also commissioned ACEEE to review our programs and provide recommendations on improvements and enhancements. Additionally, we intend to use available resources to move the market faster through the following:

- Increasing rebate levels,
- Increasing residential customer awareness through consumer education,

- Acquiring additional trained and knowledgeable staff,
- Increasing direct project management, and
- Increasing our service representative levels.

C.2.2 Demand-Side Management Objectives

Xcel Energy has a long-standing commitment to providing cost-effective and high-performing demand-side management programs. We regard conservation, energy efficiency and demand-side management to be one of the most cost-effective resource options available. Providing our customers with a full suite of programs, tools and information to conserve energy helps us meet our customers' growing energy needs and is one of our most significant efforts to reduce environmental impacts.

Our demand-side management objectives in Minnesota are to delay or avoid more expensive electricity generation, reduce pollution and other environmental impacts, and help customers save money by improving the efficiency of their homes and businesses. We consistently exceed the legislative mandate to spend at least two percent of gross electric operating revenues on energy efficiency programs and consistently achieve the conservation levels established in the resource planning process. We look forward to working with the Department and stakeholders to achieve sustainable and reliable energy savings in line with the Act.

We perform continuous assessments of our DSM programs through periodic process evaluations and market potential studies in order to identify new conservation opportunities and strategies to get more savings out of existing programs. We are actively participating in the Department of Commerce's M&V workgroup and are committed to participating in other workgroups as they are initiated.

C.3 Describe the Energy Efficiency Programs Considered, Implemented, and Why Those Considered Were Not Implemented

C.3.1 DSM Programs Consideration

Xcel Energy operates 39 individual electric DSM programs in Minnesota targeted at our Commercial & Industrial, Small Business, Consumer, and Low-Income customer segments. These programs are designed to meet both the minimum-spending requirements of Minn. Stat. § 216B.241, subd. 1(a) and the specific goals established by the Department of Commerce, most recently in Docket No. E,G002/CIP-06-80. Table C.3 below lists the specifics of the programs we currently offer and the corresponding goals for 2007 through 2009.

C.3.2 DSM Programs Implemented

Table C-3
Xcel Energy's 2007-2009 Approved DSM Programs and Goals

2007	Electric Participants	Electric Budget	Customer kW	Generator kW	Generator kWh	Gas Participants	Gas Budget	MCF Savings
Business Segment								
Boiler Efficiency						351	$628,803	238,457
Compressed Air Efficiency	82	$833,676	2,742	2,436	19,001,009			
Computer Efficiency	19,164	$179,154	239	253	2,230,207			
Cooling Efficiency	346	$1,476,190	4,654	3,147	6,748,638			
Custom Efficiency	136	$3,896,676	7,554	6,147	41,030,028	39	$866,073	310,000
Energy Design Assistance	48	$5,549,231	9,396	9,276	39,999,971	11	$159,696	15,004
Energy Management Systems	67	$745,720	1,473	25	13,073,147	13	$47,567	5,122
Furnace Efficiency						132	$49,768	3,589
Industrial Efficiency	4	$1,582,234	803	753	4,462,979	1	$70,498	6,900
Lighting Efficiency	672	$3,534,186	8,721	7,849	40,325,769			
Motor Efficiency	450	$1,717,335	4,518	3,196	25,216,289			
Recommissioning	96	$1,172,021	1,821	867	11,878,383	35	$66,870	9,000
Segment Efficiency	218	$1,612,054	507	323	2,639,195	85	$58,372	3,599
Conservation Subtotal	**21,283**	**$22,298,477**	**42,428**	**34,273**	**206,605,616**	**667**	**$1,947,647**	**591,671**
Peak Controlled Rates	111	$668,319	24,159	12,182	939,653			
Saver's Switch	2,830	$1,963,115	25,385	7,697	67,514			
Load Management Subtotal	**2,941**	**$2,631,434**	**49,544**	**19,879**	**1,007,166**			
Energy Analysis	235	$292,574				99	$96,909	
Lamp Recycling	27,344	$29,632						
Indirect Impact Subtotal	**27,579**	**$322,206**				**99**	**$96,909**	
Business Segment Total	**51,803**	**$25,252,116**	**91,972**	**54,152**	**207,612,782**	**766**	**$2,044,557**	**591,671**
Residential Segment								
Central AC Quality Installation	5,000	$1,790,815	3,878	3,161	1,618,456			
Energy Star Rebates						5,900	$634,000	76,228
High-Efficiency Showerheads						12,273	$135,241	27,001
Home Efficiency	65	$111,603	258	31	292,802	341	$451,390	20,234
Home Lighting	46,559	$310,629	2,421	447	4,000,025			
Home Performance Rebates	50	$40,351	106	44	117,234	50	$150,414	1,522
Water Heater Rebates						800	$73,741	1,440
Conservation Subtotal	**51,674**	**$2,253,397**	**6,662**	**3,684**	**6,028,516**	**19,364**	**$1,444,786**	**126,425**
Saver's Switch	20,000	$5,674,608	60,302	24,378	279,720			
Load Management Subtotal	**20,000**	**$5,674,608**	**60,302**	**24,378**	**279,720**			
Consumer Education	379,750	$414,314				267,500	$69,996	
Home Energy Audits	9,303	$407,092				3,838	$179,557	
Lamp Recycling	154,949	$162,126						
Indirect Impact Subtotal	**544,002**	**$983,532**				**271,338**	**$249,553**	
Residential Segment Total	**615,676**	**$8,911,538**	**66,964**	**28,062**	**6,308,236**	**290,702**	**$1,694,339**	**126,425**
Low-Income Segment	**1,700**	**$910,453**	**432**	**86**	**970,031**	**546**	**$931,176**	**10,990**
Expected Alternative Filings	**450**	**$6,668,646**		**5,000**	**23,322,700**			
Planning & Research Segment								
Planning								
CIP Training		$61,704					$26,449	
DSM Regulatory Affairs		$768,617					$146,421	
Research								
CIP Market Research		$424,350					$160,713	
CIP Product Development		$400,000					$50,000	
Planning & Research Total		**$1,654,671**					**$383,583**	
Supply Side Resources Segment								
University of Minnesota IREE		$2,107,374					$185,903	
Supply Side Resources Total		**$2,107,374**					**$185,903**	
2007 TOTAL	669,629	$45,504,799	159,368	87,300	238,213,749	292,014	$5,239,557	729,086

Table C-3 (continued)
Xcel Energy's 2007-2009 Approved DSM Programs and Goals

2008	Electric Participants	Electric Budget	Customer kW	Generator kW	Generator kWh	Gas Participants	Gas Budget	MCF Savings
Business Segment								
Boiler Efficiency						351	$636,769	272,206
Compressed Air Efficiency	85	$869,263	2,814	2,500	19,498,705			
Computer Efficiency	19,164	$179,564	239	253	2,230,207			
Cooling Efficiency	362	$1,497,290	4,843	3,183	6,835,463			
Custom Efficiency	123	$3,690,695	6,627	5,387	35,928,505	31	$441,104	70,000
Energy Design Assistance	48	$5,549,231	9,396	9,276	39,999,971	11	$163,695	15,004
Energy Management Systems	77	$828,896	1,699	28	15,024,415	13	$50,009	5,122
Furnace Efficiency						132	$50,384	3,589
Industrial Efficiency	10	$1,976,001	2,811	2,637	15,620,426	2	$96,698	41,000
Lighting Efficiency	539	$3,006,216	7,106	6,395	32,881,623			
Motor Efficiency	450	$1,756,293	4,518	3,196	25,216,289			
Recommissioning	105	$1,615,111	1,991	948	12,991,982	37	$79,147	9,000
Segment Efficiency	401	$2,906,945	4,139	2,824	20,677,229	142	$110,391	31,487
Conservation Subtotal	**21,364**	**$23,875,505**	**46,184**	**36,628**	**226,904,815**	**719**	**$1,628,197**	**447,408**
Peak Controlled Rates	111	$678,831	24,159	12,182	939,653			
Saver's Switch	2,830	$1,999,194	25,385	7,697	67,514			
Load Management Subtotal	**2,941**	**$2,678,025**	**49,544**	**19,879**	**1,007,166**			
Energy Analysis	242	$296,807				99	$99,913	
Lamp Recycling	27,344	$29,704						
Indirect Impact Subtotal	**27,586**	**$326,511**				**99**	**$99,913**	
Business Segment Total	**51,891**	**$26,880,041**	**95,728**	**56,507**	**227,911,981**	**818**	**$1,728,110**	**447,408**
Residential Segment								
Central AC Quality Installation	7,000	$2,330,006	5,413	4,413	2,259,435			
Energy Star Rebates						5,900	$639,419	76,228
High-Efficiency Showerheads						11,136	$123,653	24,499
Home Efficiency	85	$129,477	357	92	391,283	422	$571,630	25,038
Home Lighting Direct Purchase	52,379	$352,663	2,724	503	4,500,039			
Home Performance Rebates								
Water Heater Rebates						900	$78,390	1,620
Conservation Subtotal	**59,464**	**$2,812,146**	**8,494**	**5,008**	**7,150,757**	**18,358**	**$1,413,092**	**127,386**
Saver's Switch	20,000	$6,401,602	60,302	24,378	279,720			
Load Management Subtotal	**20,000**	**$6,401,602**	**60,302**	**24,378**	**279,720**			
Consumer Education	391,143	$427,280				275,525	$72,006	
Home Energy Audits	9,769	$426,548				4,030	$184,997	
Lamp Recycling	154,949	$162,341						
Indirect Impact Subtotal	**555,861**	**$1,016,169**				**279,555**	**$257,003**	
Residential Segment Total	**635,325**	**$10,229,916**	**68,796**	**29,386**	**7,430,477**	**297,913**	**$1,670,095**	**127,386**
Low-Income Segment	**1,700**	**$963,861**	**432**	**86**	**970,031**	**546**	**$930,269**	**10,990**
Expected Alternative Filings	**450**	**$7,044,271**		**5,000**	**23,322,700**			
Planning & Research Segment								
Planning								
CIP Training		$62,758					$26,902	
DSM Regulatory Affairs		$786,232					$150,487	
Research								
CIP Market Research		$635,145					$194,353	
CIP Product Development		$400,000					$50,000	
Planning & Research Total		**$1,884,135**					**$421,742**	
Supply Side Resources Segment								
University of Minnesota IREE		$0					$0	
Supply Side Resources Total		**$0**					**$0**	
2008 TOTAL	689,366	$47,002,224	164,955	90,980	259,635,189	299,277	$4,750,216	585,784

Table C-3 (continued)
Xcel Energy's 2007-2009 Approved DSM Programs and Goals

2009	Electric Participants	Electric Budget	Customer kW	Generator kW	Generator kWh	Gas Participants	Gas Budget	MCF Savings
Business Segment								
Boiler Efficiency						351	$644,298	289,921
Compressed Air Efficiency	87	$909,079	2,887	2,564	19,999,275			
Computer Efficiency	19,164	$179,990	239	253	2,230,207			
Cooling Efficiency	373	$1,523,400	5,025	3,213	6,915,937			
Custom Efficiency	121	$3,675,477	6,484	5,270	35,143,655	25	$415,082	57,000
Energy Design Assistance	48	$5,549,231	9,396	9,276	39,999,971	11	$167,820	15,004
Energy Management Systems	82	$871,987	1,810	30	15,971,148	13	$51,217	5,122
Furnace Efficiency						132	$51,022	3,589
Industrial Efficiency	18	$3,152,213	5,019	4,709	27,893,617	4	$130,663	62,800
Lighting Efficiency	496	$2,911,006	6,569	5,913	30,394,789			
Motor Efficiency	450	$1,750,918	4,518	3,196	25,216,289			
Recommissioning	117	$1,759,010	2,219	1,056	14,476,779	40	$79,720	9,000
Segment Efficiency	109	$1,633,876	2,399	1,641	11,919,088	32	$61,787	18,043
Conservation Subtotal	**21,065**	**$23,916,186**	**46,565**	**37,123**	**230,160,756**	**608**	**$1,601,609**	**460,479**
Peak Controlled Rates	111	$689,577	24,159	12,182	939,653			
Saver's Switch	2,830	$2,012,602	25,385	7,697	67,514			
Load Management Subtotal	**2,941**	**$2,702,179**	**49,544**	**19,879**	**1,007,166**			
Energy Analysis	252	$312,894				103	$104,731	
Lamp Recycling	27,344	$29,780						
Indirect Impact Subtotal	**27,596**	**$342,674**				**103**	**$104,731**	
Business Segment Total	**51,602**	**$26,961,039**	**96,109**	**57,002**	**231,167,922**	**711**	**$1,706,340**	**460,479**
Residential Segment								
Central AC Quality Installation	9,000	$3,055,291	6,959	5,673	2,904,718			
Energy Star Rebates						5,900	$645,967	76,228
High-Efficiency Showerheads						10,681	$118,570	23,498
Home Efficiency	102	$149,575	428	111	469,539	594	$685,015	35,489
Home Lighting Direct Purchase	58,198	$389,768	3,026	559	4,999,967			
Home Performance Rebates								
Water Heater Rebates						1,000	$85,073	1,800
Conservation Subtotal	**67,300**	**$3,594,634**	**10,414**	**6,343**	**8,374,224**	**18,175**	**$1,534,625**	**137,015**
Saver's Switch	20,000	$6,113,468	60,302	24,378	279,720			
Load Management Subtotal	**20,000**	**$6,113,468**	**60,302**	**24,378**	**279,720**			
Consumer Education	402,877	$440,654				283,790	$74,000	
Home Energy Audits	10,258	$446,948				4,231	$189,997	
Lamp Recycling	154,949	$162,563						
Indirect Impact Subtotal	**568,084**	**$1,050,165**				**288,021**	**$263,997**	
Residential Segment Total	**655,384**	**$10,758,266**	**70,716**	**30,721**	**8,653,944**	**306,196**	**$1,798,622**	**137,015**
Low-Income Segment	**1,700**	**$999,398**	**432**	**86**	**970,031**	**546**	**$945,716**	**10,990**
Expected Alternative Filings	**450**	**$7,453,702**		**5,000**	**23,322,700**			
Planning & Research Segment								
Planning								
CIP Training		$63,851					$27,369	
DSM Regulatory Affairs		$896,374					$164,839	
Research								
CIP Market Research		$817,552					$152,618	
CIP Product Development		$400,000					$50,000	
Planning & Research Total		**$2,177,777**					**$394,826**	
Supply Side Resources Segment								
University of Minnesota IREE		$0					$0	
Supply Side Resources Total		**$0**					**$0**	
2009 TOTAL	709,136	$48,350,183	167,257	92,809	264,114,597	307,453	$4,845,504	608,484

C.3.3 Reasons Why Other Programs Were Not Implemented

On an on-going basis, we review our DSM programs and consider other programs to add to our portfolio. Programs are evaluated on their cost-effectiveness and ability to achieve a certain level of market response. These criteria are influenced by a variety of factors, including changes in state or federal efficiency standards, building codes, increased availability of high efficiency technologies, technological advances and general consumer acceptance. Programs must be cost-effective in order to be implemented.

C.4 Describe Major DSM Accomplishments

Xcel Energy is a nationally recognized leader in energy conservation and load management programs. In recent years, we have received the following awards for DSM programs:

- 2007 ACEEE Exemplary Program Awards for Lighting Efficiency, Energy Design Assistance, and Center for Energy and Environment's (CEE) One-Stop Efficiency Shop
- 2007 ACEEE Exemplary Program Honorable Mention for Custom Efficiency
- 2006 Energy Star for Home Outstanding Achievement.
- 2005 Energy Star for Home Outstanding Achievement.
- 2003 Governor's Award for Excellence in Waste and Pollution Prevention for the CEE One-Stop Efficiency Shop.
- 2003 American Council for an Energy Efficient Economy Exemplary Natural Gas Conservation Program for the Energy Design Assistance and Boiler Efficiency Programs.

In addition, we have successfully managed cost-effective DSM programs for more than twenty years. We typically exceed energy efficiency goals established by the Department. From 1990 to 2006, the cumulative impact of these efforts is:

- Over $628 million in electric CIP expenditures;
- Over $2.4 billion in net utility benefits;

- 2,100 MW of demand-savings; and
- 4,100 GWh of energy-savings.

These achievements have avoided the construction of eight medium-sized (250 MW) power plants and saved enough energy to power half a million households. Furthermore, we have nearly 70 full-time employees across several areas of the company working together to design new conservation and load management programs, ensure that the savings estimates are accurate and measurable, develop marketing materials that reach the right target markets, communicate with customers one-on-one about our programs, and create plans to ensure we meet our goals.

C.5 Describe Future DSM Plans Through the Forecast Years

As discussed in previous sections, the Next Generation Energy Act of 2007 significantly increases the Company's goal requirements beginning in 2010. Future CIP plans will reflect the new goals.

C.6 Quantify How These Programs Determine the Forecast Provided in Response to 7849.0270, subpart 2

Load forecasts are based on historical load data. Therefore, the forecasted annual peak demand for electricity and annual energy consumed inherently reflect the savings due to DSM programs that have been implemented in the past. Because load forecasts are based on historic load data, a certain amount of continued DSM is already included on the forecast. This "amount" is known as embedded DSM and is roughly equal to the average annual DSM achievements obtained during the historical years. In addition to reflecting embedded DSM, the forecast is adjusted to account for the estimated savings from future DSM programs. Therefore, the total impact of DSM savings (both embedded and incremental) is fully incorporated in the forecast.

C.6.1 Total Costs by Program

The estimated costs of our Triennial programs are provided in Table C-3 above. Because the Company does not track its customers in the categories listed (farm, irrigation, non-farm residential, commercial, industrial, mining, street and highway lighting, electrified transportation, and other), we are unable to provide

information specific to those customer groups. However, in general, the listed categories fall into the following customer segments:

- Commercial & Industrial includes Commercial, Industrial, Mining;
- Small Business includes Street and Highway Lighting and Electrified
- Transportation;
- Consumer and/or Low-Income includes Non-farm Residential.

C.6.2 Discuss the Expected Effects in Reducing the Need for New Transmission and Generation

Our existing and newly developed demand-side management programs are designed to help us achieve the goals established in the 2007/2008/2009 Triennial Plan and under the new legislation. The effects of our conservation and load management programs are incorporated into the forecast of energy and demand during the modeling stage. The peak demand savings from interruptible load (associated with interruptible and direct load control programs) is subtracted from the base peak demand forecast to obtain the "net generator peak" forecast.

Appendix D: Alternative Technologies Screening

This appendix provides a detailed screening of generation technology alternatives. The alternatives are examined primarily from the perspective of technology applicability and reliability. It also provides a high level overview of economic and environmental impacts associated with the technology. Technology options are grouped as follows:

- Fossil-Fuel Technologies;
- Renewable Resource Technologies;
- Composite Resource Technologies: These alternatives are combinations of technologies that may not pass the screening as an individual resource, but have been found to be a viable option when coupled with one or more additional, complimentary resources; and
- Developing Resource Technologies.

Generation technology options that are found to be appropriate in this initial technology screening are analyzed in more detail as alternatives to the preferred proposal.

D.1 Screening Factors

D.1.1 Applicability

Applicability of the technology refers to the technology's appropriateness for the Project's operating mode. One of the objectives of the Project is to provide energy and capacity for base load service. Other service modes include intermediate load and peaking load.

While there are no strict definitions for base load, intermediate, and peaking modes of operation, the following descriptions may be helpful:

Base load resources normally operate in the range of 50 percent to 100 percent annual capacity factor, with typical capacity factors of newer base load resources being in the range of 80 percent to 90 percent. Base load resources generally have few starts per year (<10) and may be operated at reduced output levels to follow system load during off-peak periods.

Intermediate resources normally operate in the range of 20 percent to 60 percent annual capacity factor, with typical capacity factors of newer intermediate resources being in the range of 40 percent to 50 percent. Intermediate resources generally have the most starts per year of any generation resource type (> 20 and sometimes > 200), depending on the requirements of the system it serves. In recent years, intermediate resources have largely been gas-fired combined cycle facilities or older coal-fired facilities that do not have low enough variable production costs to be dispatched on a continuous basis.

Peaking resources normally operate in the range of 0 percent to 20 percent annual capacity factor, with typical capacity factors of newer peaking resources being in the range of 5 percent to 10 percent. Peaking resources are usually started only when there are very high system loads or a system operating condition develops that requires the operation of such resources over a relatively short period of time. Peaking resources usually have less than 30 starts per year.

As large regional energy markets have continued to expand, it has become possible to combine several different types of resources to meet the particular needs of a given electric system. This is especially true of conventional resources coupled with intermittent resources such as wind generation. Base load needs, for example can be served with combinations of wind and gas-fired resources or wind and hydro resources. To the extent that there are intermittent gaps in energy production from wind resources, for example, gas-fired resources that are typically used in peaking or intermediate operating mode can be dispatched as needed. Additionally, energy from large regional energy markets may be economical in many or most of the hours in which wind energy production intermittency occurs in a given year.

D.1.2 Reliability

Reliability is screened from two perspectives: operational reliability and system reliability.

Operational reliability is primarily evaluated by the availability of an alternative, which is dependent upon many factors such as maintenance requirements and availability of fuel. For a facility designed to meet the need identified and contribute towards our carbon reduction goal, availability is a significant consideration.

The evaluation of the proposed Project and alternatives must also address the commercial availability of a particular alternative technology—one that has been

commercially demonstrated to meet needs similar to those the Project has been designed to serve.

Another important factor is the alternative's implementation time. The primary activities that affect implementation time are obtaining necessary regulatory approvals, acquiring necessary transmission services, negotiating financing agreements, selecting and acquiring a site, design and engineering, procuring, construction, and testing facility equipment.

System reliability is examined from the perspective of the overall ability of an alternative to enhance the reliability of the bulk electric system. Reliability impact may be measured by an alternative's potential to reduce the frequency, duration and magnitude of adverse effects on the electric supply.

The North American Electric Reliability Council ("NERC") defines reliability as follows[1]:

> *"The degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability may be measured by the frequency, duration, and magnitude of adverse effects on the electric supply. Electric system reliability can be addressed by considering two basic and functional aspects of the electric system adequacy and security.*
>
> *Adequacy—the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking in account scheduled and reasonably expected unscheduled outages of system elements.*
>
> *Security—the ability of the electric system to withstand sudden disturbance such as electric short circuits or unanticipated loss of system elements."*

D.1.3 Environmental Impacts

Environmental impacts refer to the effects the alternative is expected to have on the environment. Potential environmental impacts associated with generation technologies include air emissions, effects on land, water consumption, wastewater generation, noise, aesthetics, and traffic.

One measure of potential overall impact to the environment is the efficiency of the technology. Efficiency quantifies how completely one form of energy can

[1] http://www.nerc.com/~filez/functionalmodel.html

be transformed into another form of energy that is more useful for a given purpose. Typically, for fossil fuel electric power generating facilities, efficiency is expressed in terms of a heat rate.

"Heat rate" is defined as[2]:

> *"a measure of average thermal efficiency of an electric generating facility expressed as the ratio of input energy per net kilowatt hour produced, computed by dividing the total energy content of fuel burned for electricity generation by the resulting net kilowatt hour generation."*

This heat rate can be converted into an efficiency percentage by dividing 3413 by the heat rate (given in units of British thermal units per kilowatt-hour) and multiplying the results by 100. "Heat rate" and "efficiency" are inversely related (i.e., the lower the heat rate, the higher the efficiency). Therefore, energy conversion projects with lower heat rates are more efficient consumers of energy resources.

While heat rate or efficiency is not a direct measure of environmental impacts, a more efficient technology many times uses fewer natural resources and may have lower environmental impacts (e.g., fewer air emissions) per kilowatt-hour of energy produced.

D.1.4 Economic Effects

Economic effects of the alternatives may include jobs created during construction and during ongoing operations, effects on regional economic development, and effects on tax revenues generated.

D.2 Fossil-Fuel Technology Screening

D.2.1 Supercritical Pulverized Coal-Fired Boiler

A supercritical pulverized coal-fired steam power plant consists of a steam boiler, a steam turbine and an electric generator side. In the simplest terms, steam is generated when water is heated by the thermal energy released when pulverized coal is burned in the boiler. The steam from the boiler is piped to,

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[2] Minn. Rules 7849.0010, Subp. 12.

and drives, a steam turbine, which in turn drives an electric generator. The term "supercritical" refers to a particular range of thermodynamic conditions (pressure and temperature) under which such a plant is designed to operate. Supercritical boilers are typically several percentage points more efficient than boilers not designed to operate under supercritical conditions.

A pulverized coal plant includes the following components:

- A large boiler that combusts coal and generates steam.
- A steam turbine generator that converts the steam's thermal energy into electrical energy.
- A coal handling system that provides coal to the boiler.
- A water treatment system that provides high quality water to the boiler steam cycle.
- A system (e.g., a cooling tower or dry cooling) to condense the exhaust steam from the steam turbine generator.
- Air pollution control equipment necessary to comply with State and Federal standards governing flue gas emissions.
- An ash disposal system that collects and stores waste ash from the coal combustion process.
- Distributed control systems to control plant equipment.
- Operations and maintenance buildings.

Fuel for the plant (coal) is typically brought to the plant by railroad or barge. Natural gas is often used as a secondary fuel and is transported to the facility via pipeline. A significant source of cooling water is required for condensing the exhaust steam from the steam turbine generator and for quenching ash produced in the boiler.

D.2.1.1 Applicability

Pulverized coal-fired facilities are best suited for base load (steady, high-capacity factor operation); however they may also serve as intermediate resources. Coal-fired units are not well suited to operate as peaking plants because of the length of time necessary for start-up (which can be a day or more) to bring a coal-fired plant on-line at full capacity. In addition, their relatively high capital costs

would become prohibitive if spread over the sub-20 percent typical capacity factor of a peaking resource.

D.2.1.2 Reliability

Pulverized coal-fired power plants are typically expected to have an annual outage rate for maintenance of 11 percent. Unplanned outages typically consume another 4 percent of the unit's availability. The net availability of coal-fired units is expected to be in the range of 85 percent. Thus, a pulverized coal-fired plant can generally demonstrate high reliability.

D.2.1.3 Environmental Impacts

Viewing environmental impacts indirectly in terms of energy efficiency (input fuel energy per kilowatt hour produced), pulverized coal-fired plants typically operate in a range of 32 to 35 percent efficiency. When designed for supercritical operating conditions, a pulverized coal-fired plant can be up to 37 percent efficient. The direct environmental impacts of coal burning include air emissions, solid waste (ash) generation, waste-heat discharge to air and water, and rail or barge traffic.

Typical carbon dioxide emission rates for new supercritical pulverized coal units are in the range of 200 lb CO2 per million btu heat input.

D.2.1.4 Economic Effects

Typically, a supercritical pulverized coal-fired power plant has high capital costs and relatively low fuel costs. Thus, it is most economically viable when serving a need for a high capacity factor resource.

Building a coal-fired power plant is a major undertaking with 12 to 24 months needed for environmental and site permitting and 36 to 60 months for construction thereafter. Transmission system upgrades necessary to accommodate a large base load facility may take 5 to 10 years to complete.

While the peak construction work force can easily exceed 1,000 personnel depending upon plant size, its contribution to the local economy is temporary. A utility-scale pulverized coal-fired generating unit typically employs 100 or more permanent staff while in operation. Power plants in Minnesota are assessed a significant local personal property tax that usually offsets some of the tax burden on other local enterprises.

D.2.2 Integrated Gasification Combined Cycle Utilizing Coal

An integrated gasification combined cycle (IGCC) power plant consists of a coal gasifier, a combustion turbine, a heat recovery steam generator and a steam turbine. In the gasifier, coal is heated to produce a "syngas" that is burned in a combustion turbine that turns a generator to produce electricity. Waste heat in the exhaust gases from the combustion turbine are used to produce steam in a heat recovery steam generator. Steam from the heat recovery steam generator is piped to, and drives, a steam turbine, which in turn drives an electric generator also.

An IGCC coal plant includes the following components:

- A gasifier that produces syngas from coal.
- A combustion turbine that burns the syngas and generates electricity.
- A heat recovery steam generator that produces steam from the waste heat in the exhaust gases from the combustion turbine
- A steam turbine that converts the steam's thermal energy into electrical energy.
- A coal handling system that provides coal to the gasifier.
- A water treatment system that provides high quality water to the heat recovery steam generator.
- A system (e.g., a cooling tower or dry cooling) to condense the exhaust steam from the steam turbine generator.
- Air pollution control equipment necessary to comply with State and Federal standards governing flue gas emissions.
- An ash disposal system that collects and stores waste ash from the gasifier.
- Distributed control systems to control plant equipment.
- Operations and maintenance buildings.

Fuel for the plant (coal) is typically brought to the plant by railroad or barge. Natural gas is often used as a secondary fuel and is transported to the facility via pipeline. A significant source of cooling water is required for condensing the exhaust steam from the steam turbine generator.

D.2.2.1 Applicability

IGCC plants are best suited for base load operating mode (steady, high-capacity factor); however they may also serve as intermediate resources. IGCC units are not well suited to operate as peaking plants because of the length of time required for start-up (which can be a day or more) to bring the plant on-line at full capacity. In addition, their relatively high capital costs would become prohibitive if spread over the sub-20 percent typical capacity factor of a peaking resource.

D.2.2.2 Reliability

IGCC technology utilizing low rank (sub-bituminous Powder River Basin) coal is a relatively new application with very limited operating data available. U.S. IGCC manufacturers claim planned maintenance and forced outage superior to supercritical pulverized coal plants with a resulting availability in range of 85 percent to 92 percent. Although these claims are somewhat untested, manufacturers are increasingly willing to offer performance guarantees to support their availability claims.

An IGCC plant is expected to demonstrate high reliability (both the adequacy and security aspects), but further operating experience is necessary to validate that expectation.

D.2.2.3 Environmental Impacts

IGCC plants are predicted to typically operate in the range of 35 percent to 40 percent efficiency. The direct environmental impacts of coal gasification include air emissions, solid waste (ash) generation, waste-heat discharge to air and water, and rail traffic.
Without CO2 sequestration, an IGCC plant is projected to have similar CO2 emissions to a supercritical pulverized coal generating plant (in the range of 200 lb CO2 per million btu fuel consumed). However, CO2 sequestration would also add significantly to the project's costs.

D.2.2.4 Economic Effects

Industry publications generally assume the costs for a new IGCC power plant to be approximately 20 – 40 percent higher than for pulverized coal plants.

Building an IGCC power plant is also a major undertaking with 12 to 24 months needed for environmental and site permitting and 36 to 48 months for construction thereafter. Transmission system upgrades necessary to accommodate a large base load facility may take 5 to 10 years to complete.

While the peak construction work force can easily exceed 1,000 personnel, its contribution to the local economy is temporary. A utility-scale IGCC generating unit is expected to employ 50 or more permanent staff while in operation. Power plants in Minnesota are assessed a significant local personal property tax that usually offsets some of the tax burden on other local enterprises.

D.2.3 Advanced Natural Gas-Fired Combined Cycle

A gas-fired combined cycle power plant is a combination of combustion turbine technology, heat recovery and electric generation. In the combustion turbine, incoming air is compressed and mixed with the natural gas fuel. Igniting this mixture results in an expansion of gases (the combustion products and excess air) through a power turbine that in turn drives an electric generator. Hot exhaust gases exiting the combustion turbine pass through a heat recovery steam generator (HRSG) to produce steam that is used to drive a steam turbine connected to a second electric generator.

Advanced gas-fired combined cycle generating units utilize large, highly efficient combustion turbines constructed with some "exotic" materials. These materials are designed to withstand the extreme operating conditions necessary to achieve high efficiency. To date, these materials have had a relatively low tolerance for thermal cycling, so combustion turbine manufacturers severely limit the number of starts per year when warranting performance of *advanced* combined cycle equipment.

Other major advanced combined-cycle plant equipment would include:

- A system (e.g., condenser or cooling tower) to condense the steam turbine exhaust steam.
- A water treatment equipment to provide high-quality makeup water to the steam cycle.
- Electrical switchgear to provide power to auxiliary plant equipment.
- Water storage tanks and fuel oil storage tanks (if applicable).
- Natural gas vaporizers.

- Possible ammonia storage if post-combustion NOx control is required.
- Operations and maintenance buildings.

D.2.3.1 Applicability

Advanced combined cycle plants are technically well suited to meet base load needs. The benefits of high efficiency must be weighed against the cost of operating such facilities on relatively high cost natural gas or fuel oil. Operating in intermediate mode will void performance warranties for new advanced combined cycle units and result in exceptionally high maintenance costs after the warranty period has expired. Thus, operation of an advanced combined cycle unit in intermediate mode is not advised. An advanced combined cycle unit can be operated in peak mode if the number of starts per year were carefully managed. However, there are more economic alternatives for peak mode operation of a gas-fired resource than an advanced combined cycle unit.

D.2.3.2 Reliability

Properly operated and maintained, combined-cycle facilities will achieve high availability. Natural gas-fired combined cycle facilities typically have fuel oil backup to address the potential interruption of natural gas supply.

A combined-cycle plant can also generally demonstrate high reliability (both the adequacy and security aspects). Natural gas-fired combined cycle facilities typically have fuel oil backup to address the potential interruption of natural gas supply.

D.2.3.3 Environmental Impacts

Environmental impacts in terms of energy efficiency (input fuel energy per kilowatt-hour produced) show distinct advantages for a combined-cycle project vs. a coal-fired plant. The energy efficiency for a combined cycle plant can be expected to be in the range of 45 to 50 percent with the efficiency of an advanced combined cycle plant exceeding 50 percent.

The direct environmental impacts of operating a combined-cycle plant burning natural gas include air emissions, wastewater discharge, waste heat discharge to air and water and the potential for on-site ammonia storage if post-combustion NOx control is required. Air emissions from an advanced gas-fired combined cycle plant are lower than that of a coal-fired plant, especially in terms of SO2

and CO2 (150 lbs per mmbtu of fuel input). A gas-fired combined cycle plant does not produce any ash.

D.2.3.4 Economic Effects

The total capital requirement for a hypothetical advanced gas-fired combined-cycle power plant are less than for pulverized coal or IGCC. However, the fuel costs are higher and subject to significant variability and volatility.

The permitting and construction time needed for an advanced combined cycle plant is typically 12 to 18 months for permitting and 24 to 36 months for construction. Transmission upgrades to accommodate such a facility on the system may take more than 5 years. While the construction work force is sizeable (> 500 at construction peak), its contribution to the local economy is temporary. A combined-cycle unit fired with pipeline natural gas will require significantly fewer staff than a corresponding coal-fired facility having to deal with major coal and ash handling operations. Thus, a combined cycle plant is not regarded as having a key impact on long-term local employment rates. A combined cycle plant would be subject to applicable property tax assessments.

D.2.4 Simple Cycle Combustion Turbine

A simple cycle power plant uses natural gas as its primary fuel and may use fuel oil as a backup fuel during times of gas supply interruption. A simple cycle combustion turbine is less expensive per KW of capacity and also significantly less efficient than a combined cycle facility because the heat from the combustion turbine exhaust gases is not recovered for secondary electric generation from a steam turbine. Ancillary equipment is likely limited to:

- Natural gas vaporizers.
- Possible ammonia storage if post-combustion NOx control is required.
- Control buildings.
- Fuel oil storage tanks (if applicable).
- A fuel forwarding system (pumps/piping/controls) to transfer fuel oil from storage to the turbine.
- Fuel heating systems for winter operations.

D.2.4.1 Applicability

Simple cycle plants are typically employed for peaking duty and are not well suited to economically meet intermediate and base load needs. Simple cycle combustion turbine generators exceeding 20 percent capacity factor would likely defer to intermediate load facilities or be considered for conversion to a combined cycle unit. Advantages of simple cycle turbine generators include flexibility in siting, relatively low capital cost and, a relatively short construction period.

D.2.4.2. Reliability

Properly operated and maintained turbine facilities will achieve high availability.

At the expense of dispatch economics, a simple cycle plant can generally demonstrate high reliability (both the adequacy and security aspects). A simple cycle combustion turbine facility may utilize fuel oil as a backup to address the potential interruption of natural gas supply. However, environmental permitting may be substantially complicated if fuel oil is utilized as a back-up fuel due to the potential for higher air emissions related to there being more sulfur in fuel oil than in natural gas. This consideration limits siting flexibility for additional units at existing peaking plant sites and/or near areas that have little available room to permit any additional air emissions.

D.2.4.3 Environmental Impacts

Environmental impacts in terms of energy efficiency (input fuel energy per kilowatt-hour produced) would not show a distinct advantage for a simple cycle turbine-driven project vs. a combined-cycle plant or a coal-fired plant. The energy efficiency for simple cycle combustion turbine generator can be expected to be in the range of 25 to 30 percent. The direct environmental impacts of operating a simple cycle plant burning natural gas include air emissions, waste heat discharge via the stack and the potential for on-site ammonia storage if post-combustion NO_x control is required.

D.2.4.4 Economic Effects

The total capital requirement for a simple-cycle gas-fired combustion turbine power plant installation is much lower than for other fossil-fuel technologies. However, the typical energy cost for a simple-cycle gas-fired combustion turbine

power plant is estimated to be much higher than for other fossil fuel units, making it a better option for meeting low capacity factor needs.

Building a simple cycle power plant is a major construction project with about a 12-18 month time frame for permitting and 12 months for construction. The time required to implement transmission upgrades necessary to accommodate the output of such a facility is highly variable, depending on the particular site chosen. The positive impact of the construction work force on the local economy is temporary. A simple cycle unit fired with pipeline natural gas will require significantly fewer staff than a corresponding coal-fired facility having to deal with major coal and ash handling operations. Thus a simple cycle plant could not be regarded as having a key impact on long-term local employment rates. Certain components of a simple cycle driven power plant would be subject to local property tax assessments.

D.2.5 Summary of Fossil-Fuel Technologies

Based on this initial screening, several fossil-fuel technologies have similar operating characteristics (base load) of the Prairie Island nuclear plant. However none of these can be economically built to a similar size as the uprate project. Also, with the exception of the simple cycle combustion turbine, none of the fossil-fueled could likely be constructed in time to meet the 2011 in-service date of the uprate project. Therefore none of the typical fossil fuel technologies were include in the second stage quantitative evaluation as stand alone construction projects. However, while we are unaware of a specific project that would be available in 2011, we did include, due to the similar operating characteristics between coal and nuclear generation, we did include an equivalent sized (71 MW) coal purchased power contract in the quantitative evaluation for direct comparison.

D.3 Renewable Resource Technology Screening

D.3.1 Wind

Wind energy technology consists of a set of wind-driven turbine blades that turn a mechanical shaft coupled to a generator, which in turn produces electricity. The major components of the wind turbine include:

- Rotor blades
- Gear box
- Generator
- Nacelle (gearbox/generator housing)
- Tower
- Collection system of electrical lines connecting a number of wind turbines to a substation (applicable only to multiple wind turbine projects).

Wind turbines are either horizontal axis or vertical axis machines, which make full use of lift-generating air flows. Each type of turbine has advantages and disadvantages. The vast majority of wind turbines on the market currently utilize horizontal axis technology. Horizontal axis turbines are typically built with two or three turbine blades. Turbines for utility applications are normally installed in clusters of 5 to 200 megawatts, and may be referred to as wind farms.

D.3.1.1 Applicability

Wind turbines can help meet overall system energy needs, but offer inadequate dispatch flexibility to support intermediate or peaking load needs. Wind generation can help meet base load energy needs, but cannot meet the capacity component of base load needs on its own; it must be coupled with other technologies or resources from the energy markets.

Utilization of taller wind turbine towers and the ever-greater geographic diversity of wind resources in the region will reduce the intermittency of wind generation on a system-wide basis and, thus, offer a correspondingly greater capacity contribution to base load capacity needs. However, such outcomes are still in the study phase and subject to validation over time.

D.3.1.2 Reliability

Wind turbines are generally expected to have a high availability, but actual availability is dependent on the quality of wind resources of the geographic location in which the resource is located. Even when wind energy is present, wind turbines can only generate power within an optimum range of wind speeds.

A wind turbine installation cannot have an objective of providing a guaranteed performance from the perspective of the utility customer. At best, wind-generated power can replace a percentage of base load generation during periods of low to moderately high wind conditions and subsequently conserve fossil fuels. The use of wind energy to meet base load or intermediate load needs is best when coupled with additional generation resources.

D.3.1.3 Environmental Impacts

Wind turbine generation has many environmental advantages over fossil fuels because there are no air emissions nor solids or water discharges associated with operating the turbines. Turbines may encounter some siting opposition with regard to noise and aesthetics. In many cases, the original use of the land (i.e., agriculture) can continue in the presence of the turbine installation with less than 5 percent of the original land area taken out of production.

D.3.1.4 Economic Effects

The total costs associated with wind vary according to market conditions. Two important factors are the availability of the production tax credit and supply conditions for wind turbines.

Building a wind farm project, like other power projects, would utilize a significant work force for the duration of the construction. Operating a wind farm does not require a large staff. Wind power electricity often qualifies for tax credits or production incentives on a cents-per-kilowatt basis.

Permitting and construction for large wind turbine installations can be completed in as little as 12 to 24 months. However, transmission upgrades necessary to accommodate energy production from wind turbines may take as long to implement as transmission upgrades for other base load options, particularly in areas where significant wind generation development has already occurred (i.e., Buffalo Ridge) or where little or no transmission infrastructure currently exists.

D.3.2 Solar

Solar energy to electricity conversion technologies include thermal conversion (typically using sunlight to generate steam to turn a turbine) and photovoltaic

(direct conversion of sunlight to direct current power). Thermal, or concentrating solar power technology (parabolic troughs, power towers, and dish/engine systems), converts sunlight into electricity efficiently with minimal effects on the environment. Trough systems predominate among today's commercial solar-powered plants.

Trough systems focus the sun at 30 to 60 times its normal intensity to heat a heat transfer fluid (synthetic oil). The hot oil is pumped to a generating station heat exchanger to produce steam. Finally, electricity is produced in conventional steam turbine generators. Trough systems may be configured as hybrids to operate on natural gas on cloudy days or after dark.

The "photovoltaic effect" is the basic physical process through which a photovoltaic (PV) cell converts sunlight into electricity. Solar energy (composed of photons) is transferred to the electrons of atoms making up the PV cell. Higher energy electrons begin to flow and become electric current. By grouping single PV cells into arrays, and then placing many arrays together, power plants of up to 6.5 megawatts have been built.

D.3.2.1 Applicability

The applicability for solar generation to meet capacity needs is defined primarily by problems with reliability. Solar power systems generally represent even less capacity than a wind turbine installation and, combined with a dependence on quality insolation rates, cannot meet intermediate load and peaking service needs. Siting of a large solar power plant is also predicated on locating candidate areas that have the solar energy data that would support the project economics. The Southwest United States, rather than Minnesota, is usually considered the prime location for significant solar generation efforts.

D.3.2.2 Reliability

Solar generating facilities are generally expected to have a high availability, but actual availability is dependent on the quality of solar resources of the geographic location in which the resource is located.

A solar power installation cannot meet an objective of providing a guaranteed performance to the end user of generated power. The hybrid design of some solar plants, utilizing natural gas during periods of poor solar intensity, acknowledges that solar energy cannot be depended upon to maintain a capacity rating.

D.3.2.3 Environmental Impacts

Solar power generation has many environmental advantages over fossil fuels because there are no air emissions or solids discharges associated with operating the systems. Trough/gas hybrid systems do utilize a steam loop, which requires process and cooling water, some water treatment and some wastewater discharge (blowdown).

D.3.2.4 Economic Effects

The total capital requirement for either a photovoltaic power plant or a trough/gas hybrid plant continues to be significantly higher than for other resources, making it cost prohibitive for large-scale applications. Building a solar generation project, like other power projects, could utilize a significant work force for the duration of construction. Operating solar generation facilities does not require employing a large staff.

D.3.3 Biomass (Direct-Fired)

The process of direct-firing biomass fuels is very similar to the firing of other solid fuels. Fuel handling and storage, fuel firing, ash handling and disposal, air emissions, water consumption, and wastewater management will have many similarities to coal-fired systems. The primary activity steps for a biomass plant include:

- Biomass fuel receiving;
- On-site processing (size reduction, drying, screening);
- Fuel storage/conveying;
- Boiler (usually a stoker design);
- Ash and flue gas handling;
- Air emission controls (baghouse/ESP for particulate; ammonia for NO_x control);
- Steam turbine; and
- Cooling tower.

Biomass fuels can be harvested from the forest, collected as waste materials from processing plants or agriculture, or grown in biomass plantations. Fuel

may be shipped to the power plant by truck, rail or barge depending on the plant location and type. Fuel will generally be stockpiled as insurance against interruptions in supply. Depending on fuel characteristics, drying and size reduction may be necessary prior to firing. Drying is sometimes accomplished by utilizing the heat from stack gases. Prepared fuel is fed to the furnace and the resulting heat is used to generate steam. The steam from the boiler is piped to, and drives, a steam turbine, which in turn drives an electric generator to produce saleable electrical power.

D.3.3.1 Applicability

A biomass facility may serve as an intermediate load unit; however, biomass-fired power boilers are best suited for base load (steady, high-capacity) duty. Boiler-based biomass-fueled plants are not well suited to operate as peaking plants because of the long lead time (a day or more) necessary to bring a solid fuel-fired plant on-line at full capacity. The forest products and agriculture industries in Minnesota and the Midwest offer a wide and expanding variety of biomass fuels.

D.3.3.2 Reliability

The net availability of biomass-fired units is expected to be reasonably high, potentially 85 percent.

A biomass-fired plant can generally demonstrate high reliability (both the adequacy and security aspects) for base load and intermediate load service if an adequate supply of fuel is available. Overcoming the logistical and economic challenges of collecting enough fuel to support the operation of a biomass-fueled power plant at a nominal 85 percent capacity factor is a substantial undertaking. Competition for economic fuel feedstocks can be fierce, depending on the feedstock(s) in question and the location of the biomass-fueled plant. This has been especially true of forest product waste fuels and urban wood waste fuel feedstocks.

D.3.3.3 Environmental Impacts

Waste streams from the furnace include stack gases, bottom ash, and boiler water blowdown. Bottom ash produced in many biomass combustion plants is often of a quality that can be sold, or used as a soil conditioner/fertilizer due to the lack of many trace metals, which often contaminate coal ash. Boiler

blowdown, along with other process wastewater streams, will typically be treated to remove solids, oils, and grease prior to discharge. Cooling water used to condense the steam exhausted from the turbine would most likely be cooled using a direct-contact cooling tower. The use of a cooling tower represents a significant consumption of water.

The stack gases will contain particulate matter as well as gaseous pollutants – depending upon the fuel source used. If a thermal drier with auxiliary firing is used, the drying step will increase energy use and environmental emissions. Typically, stack gases will pass through an air pollution control device where particulate matter is removed. A large new boiler will likely be required to also address the control of NOx and CO emissions.

Viewing environmental impacts indirectly in terms of energy efficiency (input fuel energy per kilowatt hour produced), biomass-fired plants typically operate in a range of 20 – 30 percent efficiency. Biomass power production is affected by a greater variability in biomass fuel quality than is coal-fired power production. Variability in moisture and ash content are characteristic of a diverse fuel source and leads to variability in heat value on a mass basis. The direct environmental impacts of biomass burning are similar to those for coal combustion and include air emissions, solid waste (ash) generation, waste heat discharge to air and water, and truck and/or rail traffic.

A biomass plant utilizing a closed-loop biomass fuel, such as switchgrass or hybrid poplar trees, would have less environmental impact per unit of energy produced with regard to CO2 emissions because the uptake of CO2 during the growth of fuel feedstocks would offset CO2 emissions from the plant when the fuel was burned.

D.3.3.4 Economic Effects

The total capital requirement for a biomass power plant is highly variable and size dependent. Higher capacity plants will generally be less expensive. Due to the variability, it is important to analyze specific proposals before making cost estimates. Building a biomass-fired power plant is a major construction project with 12 to 24 months required for permitting and 24 to 36 months for construction. Transmission upgrades necessary to support such a project could take as long to implement as the transmission upgrades for other types of base load options. The relatively small size of biomass power plants (under 100 MW) could minimize the transmission upgrades implementation timeframe.

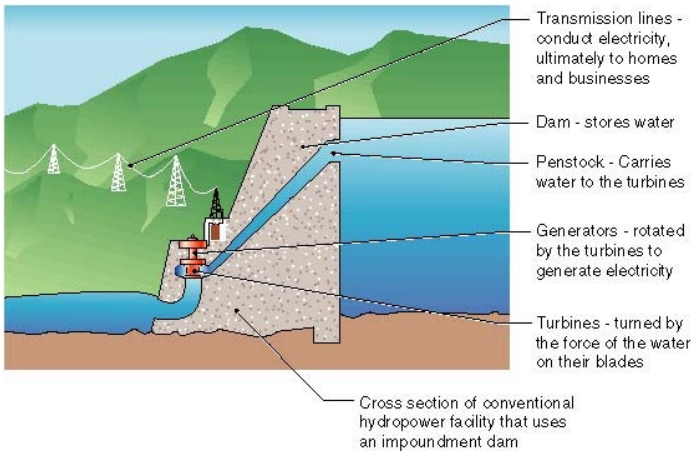
While the construction work force is of a significant size, its contribution to the local economy is temporary. The long-term operation of a biomass power plant would not be regarded as having a large impact on local employment rates via plant staffing. The creation of a (larger) biomass-for-fuel market may be an opportunity for farmers and landowners to exploit biomass materials that would otherwise be neglected as an income-producing source.

The plant would be subject to applicable property taxes that can be viewed as likely offsetting the tax burden on other local enterprise.

D.3.4 Hydropower

Hydroelectric power plants convert the potential energy of water, pooled at a higher elevation, into electricity by passing the water through a turbine and discharging it at a lower elevation. The water turns the turbine connected to an electric generator, thus producing electrical energy. The turbines and generators are installed in, or adjacent to, dams, or use pipelines (called penstocks) to carry the pressurized water below the dam or diversion structure to the powerhouse. Hydropower projects are generally operated in a run-of-river, peaking, or storage mode.

Run-of-river projects use the natural flow of the river and produce relatively little change in the stream channel and stream flow. A peaking project impounds and releases water when the energy is needed. A storage project extensively impounds and stores water during high-flow periods to augment the water available during low-flow periods, allowing the flow releases and power production to be more constant. Many projects combine the modes.



The capacity of a hydropower plant is primarily a function of two variables: (1) flow rate expressed in cubic feet per second (cfs); and (2) hydraulic head which is the elevation difference the water falls in passing from the reservoir through the turbine. Depending on the particular waterway being considered, project design may

concentrate on either of these variables (high head/low flow or low head/high flow). Most conventional hydropower plants include the following major components:

- Dam — controls the flow of water and increases the elevation to create the heat. The reservoir that is formed is in effect stored energy.
- Penstock — carries water from the reservoir to the turbine in a power plant.
- Turbine — turned by the force of water pushing against the blades.
- Generator — connects to the turbine and rotates to produce the electrical energy.

The principal advantages of using hydropower are its large renewable domestic resource space, the absence of polluting emissions during operation, its capability in some cases to respond quickly to utility load demands, and its very low operating costs. Disadvantages can include high initial capital costs and potential site-specific and cumulative environmental impacts.

D.3.4.1 Applicability

Hydroelectric plants are operated in several modes. Plants with large water storage capability lend themselves well to peaking power production and hydroelectric plants are able to come on line much quicker than steam generating systems. Run-of-river plants are more likely to produce a more constant power output though that output is dependent on water levels and, in cold climates, ice conditions.

The U.S. Department of Energy's (DOE) Hydropower Program has estimated that there is additional hydropower in this region. While it is possible that some of the identified potential hydropower could be developed, decisions to do so would need to also consider that transmission systems may not exist in remote areas containing hydropower potential. Development of hydropower, and associated transmission systems, faces the scrutiny of a general environmental trend toward releasing water reservoirs where possible. Developing capacity of a hundred MW or more would require development of multiple existing and/or potential hydropower sites. Such an effort would take several years of environmental study and negotiation to acquire water use and land rights, and permits and licensing for dams and/or transmission lines.

D.3.4.2 Reliability

During periods of normal precipitation and ice-free conditions, the availability of established hydropower generation is typically very high.

The hydropower sector of power generation is well established with proven technologies installed as standard design. In mechanical terms, hydroelectric plants are highly reliable.

Because hydropower depends on water flow, hydroelectric plants are susceptible to fluctuations in output as a function of weather patterns. Reliability can suffer during periods of drought or during periods of freezing conditions in northern climates. Weather-induced fluctuation in power output may be less pronounced than it is for wind or solar power; however, for long-term planning to meet projected demand, hydropower may be better suited to reliably provide peak load capacity.

D.3.4.3 Environmental Impacts

Hydropower projects are not sources of the typical air and water emissions and solid waste disposal issues associated with solid fuel-fired power production; however, hydropower has faced scrutiny for its significant environmental impacts. More recent projects benefited from early experience to be able to minimize or offset impacts of altered river basin hydrology, fish mortality, fish migration interference, decrease in water quality, and flooding of land.

D.3.4.4 Economic Effects

The total capital requirement for a hypothetical hydropower power plant can be very high, although the all-in energy requirements are reasonable as compared to other alternatives. Most of the potential sites within the region have capability of less than 10 MW and economies of scale would not be realized. Annual operating expenses would likely be less than for a fuel-fired power plant because the hydropower energy source (pooled water) is not typically a purchased input.

Building a hydroelectric power plant is a major construction project with a several-year time frame. While the construction work force is of a significant size, its contribution to the local economy is temporary. The long-term operation of a hydroelectric power plant would not be regarded as having a large impact on local employment rates via plant staffing. The creation of a new

reservoir does have the potential for creating commerce from recreational activity if fisheries and surrounding land area are developed to attract the public.

D.3.5 Landfill Gas

The most common use of landfill gas (LFG) is for on-site electricity generation by firing stationary engine generator sets. Some LFG is used to fire boilers or turbines and LFG, sufficiently processed, could be an energy source for fuel cell operation. Electric generating plants using LFG and those using natural gas or distillate oil are nearly identical; however, firing LFG does require gas processing and careful monitoring of equipment because LFG tends to be more corrosive. Significant quantities of LFG are emitted from municipal solid waste where it has been deposited in landfills; however, LFG typically has a medium Btu content and is not typically a source of energy on a scale larger than a few MW.

LFG recovery for energy is practiced in the United States, Europe and other countries around the world. A typical system consists of the following components[3]:

- The gas collection system, typically a series of wells strategically placed throughout the landfill, which gathers the gas being produced within the landfill;
- The gas processing system and engine/generator set, which cleans the gas and converts it into electricity; and
- The interconnection equipment, which delivers the electricity from the project to the final use.

[3] U.S. Department of Energy/National Renewable Energy Laboratory, a DOE national laboratory; DOE/CH10093-322; DE94006897; May 1994, Revised October 1994; http://www.eren.doe.gov/cities_counties/landfil1.html

D.3.5.1 Applicability

LFG power generation projects are generally sited on large landfills and produce power in the range of kilowatts to a few megawatts. The driver for LFG power generation is the utilization of a fuel source that would otherwise be flared to avoid an explosion hazard and to avoid an emission source by producing saleable energy. A LFG plant could reasonably be viewed as an emission control technology. LFG does not exist at the levels needed to support large energy needs.

D.3.5.2 Reliability

The availability of a LFG-fired generation system is expected to be high, similar to systems firing natural. However, the corrosive nature of landfill gas does introduce more potential for equipment problems.

Because of the small-scale nature of most LFG plants, a LFG power installation project typically does not have an objective of providing a guaranteed performance from the perspective of the utility customer. Power output for LFG plants depends upon the LFG production rate that does not adjust to power demand. LFG-generated power can replace a percentage of base load generation and subsequently conserve fossil fuels.

D.3.5.3 Environmental Impacts

LFG projects are expected to be a net benefit to the environment by reducing the amount of LFG emissions to the atmosphere; however, some of the landfill emission reductions are offset by the combustion emissions such as NO_x and CO from the combustion equipment. From an energy efficiency perspective, LFG collection systems (i.e., the well networks) are not totally efficient, and combined with the inherent inefficiencies of combustion equipment, the overall energy efficiency of an LFG system generally less than 30 percent.

D.3.5.4 Economic Effects

The total capital requirement for developing a hypothetical LFG power plant is not very high and all-in costs are also quite competitive. However, the LFG volumes do not exist within one site necessary to fuel a plant with a hundred MW or higher capacity. Most landfill sites will not support more than 10 MW of generation. Annual operating expenses may be less than for a typical fuel-

fired power plant because the LFG is not typically a purchased input. However, some municipalities associated with landfills may require a royalty to be paid from energy sales.

The long-term operation of a LFG power plant would not be regarded as having a large impact on local employment rates via plant staffing.

Because of its limited availability, LFG is not a viable alternative for our current need. However, it performs well as a resource and we will continue to evaluate all LFG projects as they arise and pursue cost-effective landfill gas opportunities.

D.3.6 Summary of Renewable Resources

Based on the initial screening, only the biomass alternative has the appropriate characteristic to be included in the second stage quantitative analysis. The wind and solar options do not have comparable reliability due to the variability of the energy production. The hydro resource cannot be expected to be available in time for the 2011 in-service date. The landfill gas option likely cannot be acquired in sufficient quantity to provide the equivalent size and capacity to the Prairie Island upgrade project.

D.4 Developing Technologies Screening

D.4.1 Fuel Cells

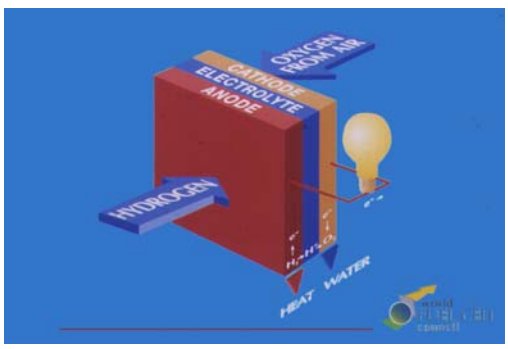
A fuel cell converts energy directly, without combustion, by combining hydrogen and oxygen electrochemically to produce water, electricity, and heat. Fueled with pure hydrogen, they produce no pollutant emissions. Even if fueled with natural gas as a source of hydrogen, emissions are orders of magnitude below those for conventional combustion generating equipment. The principle of operation of a typical fuel cell consists of the following processes:

- When hydrogen is fed into a fuel cell a catalyst on the anode converts hydrogen gas into negatively charged electrons (e^-) and positively charged ions (H^+).
- The electrons (e^-) flow through an external load to the cathode.

- The hydrogen ions (H^+) migrate through the electrolyte to the cathode where they combine with oxygen and the electrons (e^-) to produce water.

There are a variety of fuel cell designs (referring mainly to the electrolyte style) including solid oxide, alkaline, phosphoric acid, molten carbonate, and proton exchange membrane. The main components of a fuel cell system include:

- A porous anode (example materials are graphite, and nickel, chromium and zirconium alloys);
- An electrolyte (example phosphoric acid)
- A porous cathode (same materials as anode);
- Precious metal catalyst;
- Fuel reformer (to generate hydrogen from fossil fuel); and
- Power conditioner (to convert from DC to AC and to regulate power production in accordance with load).



D.4.1.1 Applicability

Fuel cell installations are viewed as an extended generation strategy and thus are typically sited adjoining the end user. Currently, fuel cell installations remain small, just a few megawatts. The fuels potentially used by fuel cell installations are widely available.

D.4.1.2 Reliability

Power industry estimates for significant fuel cell technology implementation range from 5 to 10 years. As design improves with experience, fuel cells will provide high availability.

Fuel cells have demonstrated high reliability in pilot installation settings. Current manufacturing capacity of fuel cells is not yet established to the point where fuel cell installations are expected to address significant demand.

D.4.1.3 Environmental Impacts

Fuel cells can boast great potential for improving energy efficiency. Fuel cells generate significant quantities of waste heat that can be recovered in a cogeneration configuration. The proximity of fuel cells to the end user of generated power greatly reduces transmission losses.

Fuel cell environmental impacts directly related to operating the cell are minimal. By eliminating the combustion step of fossil fuel utilization, air emissions are virtually eliminated relative to conventional fuel-fired power generation. Indirect impacts may arise if a preliminary fuel processing step (e.g., coal gasification) is utilized to provide fuel for a fuel cell.

D.4.1.4 Economic Effects

The total capital requirement for developing a hypothetical fuel cell power plant is estimated to be prohibitively high. The size of fuel cell installations would require hundreds of fuel cell sites to provide capabilities in the range of a hundred MW or more. Fuel cells, individually, will require maintenance, but will be too small to create a noticeable impact on local employment statistics.

D.4.2 Microturbines

Microturbines are a type of combustion turbine that is used for stationary energy generation applications. They are usually small units (common refrigerator size) with outputs that are very small, usually in the kilowatt range. Microturbines operate similar to a combustion turbine except on a much smaller scale. Generally, microturbines contain the following design features:

- Radial flow compressors;
- Low pressure ratios (single or possibly two stage compression);
- Minimal use of van or rotor cooling;
- Recuperation of exhaust heat for air preheating;
- Use of materials that are amenable to low cost production; and
- Very high rotational speeds on the primary output shaft (25,000 rpm or more).

Microturbines are capable of using many alternative/optional fuels including natural gas, diesel, ethanol, landfill gas, and other biomass-derived liquids and gases.

D.4.2.1 Applicability

Microturbines are well suited to meet intermediate, base load, peaking, or co-generation load needs. High kW output needs may not be feasible because existing power conditioning equipment does not allow easy interconnection between microturbine systems.

D.4.2.2 Reliability

Microturbines have relatively few moving parts and can operate continuously with little maintenance. Existing microturbine based power generation systems have demonstrated extremely high availability.

Microturbine systems can generally demonstrate high reliability (both the adequacy and security aspects). Natural gas-fired systems typically do no have alternative fuel options for backup. A reliable natural gas or other primary fuel source is required to have a reliable system.

D.4.2.3 Environmental Impacts

Environmental impacts in terms of energy efficiency (input fuel energy per kilowatt-hour produced) show a distinct disadvantage versus combined-cycle and coal-fired plants. Direct environmental impacts of operating a natural gas combustion microturbine include air emissions and waste heat discharge. Microturbines have manufacturer listed NOx levels from 9 to 50 ppm (typical generator natural gas combustion sources range from 45-200 ppm NOx).

D.4.2.4 Economic Effects

The total capital requirement for a microturbine power plant varies significantly, making it important to evaluate specific proposals before making economic conclusions. However, at this time large-scale implementation of this resource does not appear to be feasible.

D.4.3 Energy Storage

The application of energy storage technologies is best suited to peaking power needs since it presumes that there is excess or underutilized generating capacity at some point during which energy can be stored and released at a later point in time. Energy storage technologies have long been considered as a means of leveling the load on existing generating plants, thus allowing them to operate closer to their peak efficiencies. Energy storage is not well suited for meeting base load energy needs and must be combined with other energy resources to address reliability issues. Four storage technologies are discussed here - battery energy storage systems (BESS), compressed air energy storage (CAES), pumped storage hydroelectric, and flywheel energy storage.

Portions of the following discussion are based on information contained in the U.S. DOE/EPRI topical report on renewable energy technologies.[4]

D.4.3.1 Battery Energy Storage System (BESS)

There are currently a wide variety of types of batteries available for use in energy storage applications. In a chemical battery, charging causes reactions in electrochemical compounds to store energy charged to the battery in a chemical form. When a load is applied to the battery, reverse chemical reactions allow the energy to be drawn from the battery. Commercially available batteries range in size from kilowatts to modular configurations of several megawatts.

D.4.3.2 Compressed Air Energy Storage (CAES)

CAES plants are designed to use off-peak energy from existing power plants to compress air and store it in air-tight underground caverns. When called upon, the air is released, heated, and expanded through a gas turbine to recover the energy. Although manufacturers offer equipment to construct CAES systems ranging up to 350 MW, to date only a 110 MW plant has been constructed in Alabama. The Electric Power Research Institute (EPRI) has estimated that more than 85 percent of the United States may have geological characteristics that would allow for CAES construction.

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[4] U.S. DOE and EPRI. December 1997. "Renewable Energy Technology Characterizations", EPRI Topical Report TR-109496, www.eren.doe.gov/utilities/techchar.htm.

D.4.3.3 Pumped Storage Hydroelectric

Pumped storage hydroelectric plants pump the water resource, usually through a reversible turbine, from a lower reservoir to an upper reservoir. While pumped storage facilities are net energy consumers, they are valued by a utility because they can be rapidly brought on-line to operate in a peak power production mode. The pumping to replenish the upper reservoir is performed during off-peak hours when electricity costs are lowest. This process benefits the utility by increasing the load factor and reducing the cycling of its base load units. In most cases, pumped storage plants run a full cycle every 24 hours.

D.4.3.4 Flywheel Energy Storage

The concept behind this technology is to store energy in a spinning flywheel. An integral motor/generator is connected to the flywheel and can be used to either charge energy to the flywheel or extract energy from it. This technology has been applied to mechanical systems and is now receiving attention towards applying it to electrical systems. Commercially available flywheels constructed of steel are limited in size due to the potential for catastrophic failure. Advanced composite wheels have been designed but are not yet commercially available. Small demonstration systems, rated in the kilowatt range, have been constructed. Large-scale application of the technology has not been demonstrated.

D.4.4 Applicability

Energy storage projects require an energy producer with excess or underutilized generating capacity to charge the storage system. Where this excess capacity exists, energy storage technologies are a means of leveling the load on existing generating plants thus allowing them to operate closer to their peak efficiencies. However, energy storage technologies do not meet intermediate or base load energy needs well.

D.4.5 Reliability

By their nature, energy storage systems have high availability so that power may be readily extracted and used. These systems would typically back up less reliable parts of the overall electric supply system and are best suited for peaking power needs.

Implementation times for the energy storage technologies discussed here would be variable due to the differences in issues between them. Small, disperse battery and flywheel systems could likely be installed within months, whereas CAES and pumped storage hydro facilities may require years of development effort likely involving contentious approval processes.

D.4.6 Environmental Effects

Quantitative values for efficiency of each system have not been identified. A feature of all storage systems is that less energy will be extracted than was originally stored. The process of storage requires an energy expenditure that cannot be recovered.

None of the four systems discussed here will directly release air pollutant emissions in significant amounts. Pumped storage hydro development will have impacts similar to any hydroelectric project development. Substantial areas of land and habitat may be lost due to hydro development. None of the technologies discussed here would discharge significant quantities of wastewater or noise.

D.4.7 Economic Effects

The capital costs for constructing an energy storage facility are variable and dependent on technology selection. However, as noted previously, energy storage projects require an energy producer to charge the storage system. The costs for energy storage typically assume that underutilized energy production facilities exist. Operating costs are primarily dependent upon the operating costs associated with the original energy source.

The economic benefits derived from development of energy storage projects may be limited to minor increases in employment levels and property tax benefits.

D.5 Summary of Developing Technologies

None of the developing technologies pass the initial screening as being viable for current implementation to meet our need. However, we will continue to monitor technology development and identify opportunities for utilizing emerging technologies.

RADIATION PRIMER

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1.0 INTRODUCTION

This is a brief primer on radiation for readers who do not have a technical background in radiation science but require some knowledge about radiation, its public health impacts, and how it is controlled.[1] This primer covers the following subject material: characteristics of ionizing radiation, quantities and units used to measure radiation, sources of radiation, public health effects, and principles of radiation safety.

Radiation is an integral part of life. We live in a world in which radiation is naturally present everywhere. Light and heat from nuclear reactions in the Sun are essential to our existence. Radioactive materials occur naturally throughout the environment, and our bodies contain radioactive materials such as carbon-14, potassium-40 and polonium-210 quite naturally. All life on Earth has evolved in the presence of radiation. Without radiation life on Earth as we know it would not exist.

Radiation also can be made by man. This includes hundreds of beneficial uses, including medical X-rays, nuclear medicine pharmaceuticals, television sets and electricity generation from nuclear power plants. Man-made radiation is basically no different from naturally occurring radiation. But, unlike natural background radiation, the use and handling of man-made radiation is strictly controlled and regulated. Most of the public's exposure to man-made radiation comes as a result of medical X-rays, as well as other medical diagnostic treatments using radioactive materials. Nuclear power operations including storage of spent nuclear fuel exposes the population to only a tiny amount of radiation.

2.0 WHAT IS IONIZING RADIATION?

Radiation may be defined as the transport of energy in the form of waves or particles through space. Radiation can be classified according to the effects that are produced when radiation interacts with matter. *Ionizing radiation* (e.g. cosmic rays, X rays and the radiation from radioactive materials) have sufficient energy to ionize the irradiated material. *Non-ionizing radiation* (e.g., ultraviolet light, radiant heat, radio waves and microwaves) have insufficient energy to cause ionization but, nonetheless may cause damage through other physico-chemical processes. In this

1. This paper is based on various publications from the Nuclear Energy Institute and by the International Atomic Energy Agency. The Nuclear Energy Institute has developed a series of primers and reports for non-technical audiences. These may be found at: http://www.nei.org/index.asp?catnum=1&catid=6
The International Atomic Energy Agency has published an excellent document titled *Radiation, People and the Environment*. It may be accessed at:
http://www.iaea.org/Publications/Booklets/RadPeopleEnv/pdf/radiation_low.pdf

primer only ionizing radiation is considered. Ionizing radiation is produced by radioactive materials that are key components in the nuclear fuel used in electricity generation in nuclear power plants.

2.1 Radionuclides and radioactivity

Radionuclides (nuclides that are radioactive and emit radiation) are an important source of ionizing radiation. Atoms can be characterized by the composition of the atomic nucleus. *Nuclides* are defined as a species of atom with a given number of protons and neutrons in the nucleus. Chemical and physical properties of a nuclide are determined by the number of neutrons and protons in the nucleus. All nuclides with the same number of protons in the nucleus (but different numbers of neutrons) are called *isotopes* and share the same chemical properties.

Although many nuclides are stable, most are not. An unstable nuclide is called a *radionuclide*. Stability is determined mainly by the balance between the number of neutrons and protons a nuclide contains. Smaller stable nuclides have about equal numbers of protons and neutrons; larger stable nuclides have slightly more neutrons than protons. Radionuclides with too many neutrons are unstable and tend to transform themselves to a more stable structure by converting a neutron to a proton: this process, known as beta decay, results in the emission of a negatively charged electron called a *beta particle*. Radionuclides with too many protons are also unstable and convert the excess protons to neutrons in a different form of beta decay; they lose positive charge through the emission of a *positron*, which is a positively charged electron.

These transformations often leave the nucleus with excess energy that it loses as *gamma rays* — high energy *photons*, which are discrete parcels of energy without mass or charge. The spontaneous transformation of a radionuclide is called *radioactivity,* and the excess energy emitted is a form of ionizing radiation. The act of transformation is termed *radioactive decay*.

Some very heavy radionuclides decay by producing an *alpha particle* consisting of two protons and two neutrons. Identical with a nucleus of helium, the alpha particle is much heavier than the beta particle and carries two units of positive charge.

2.2 Alphas, betas, gammas and neutrons

Alpha particles, beta particles, gamma rays and neutrons are products of the decay of radionuclides important in nuclear power plant operations. Nuclear fuel contains radionuclides that produce these forms of ionizing radiation:

Alpha radiation is a positively charged helium nucleus emitted by large, unstable nuclei. It is a relatively massive particle, but it only has a short range in air (1–2 cm) and can be absorbed completely by paper or skin. Alpha radiation can, however, be hazardous if it enters the body by inhalation or ingestion because large exposures can occur in nearby tissues, such as the lining of the lung or stomach.

Beta radiation is an electron emitted by an unstable nucleus. Beta particles are much lighter than alpha particles and can penetrate further into materials or tissue. Beta radiation can be absorbed completely by sheets of plastic, glass, or metal. It does not normally penetrate beyond the top layer of skin. However large exposures to high-energy beta emitters can cause skin burns. Such emitters can also be hazardous if inhaled or ingested.

Gamma radiation is a very high energy photon (a form of electromagnetic radiation like light) emitted from an unstable nucleus that is often emitting a beta particle at the same time. Gamma radiation causes ionization in atoms when it passes through matter, primarily due to interactions with electrons. It can be very penetrating and only a substantial thickness of dense materials such as concrete, steel or lead can provide good shielding. Gamma radiation can therefore deliver doses to internal organs without inhalation or ingestion.

Neutron radiation is a neutron emitted by an unstable nucleus, in particular during atomic fission and nuclear fusion. Apart from a component in cosmic rays, neutrons are usually produced artificially. Because they are electrically neutral particles, neutrons can be very penetrating. Neutrons interact with matter or tissue in complex ways including collisions with protons (i.e., hydrogen atoms) and can cause the emission of beta and gamma radiation if the neutron is absorbed by an atomic nucleus. Neutron radiation therefore requires heavy shielding to reduce exposures.

3.0 RADIATION QUANTITIES AND UNITS

Ionizing radiation cannot be detected by our senses. But indirect methods are available that take advantage of the fact that ions are produced when radiation interacts with matter. Common methods of detection include *photographic films, Geiger–Müller tubes*, and *scintillation counters*, as well as newer techniques using *thermoluminescent materials* and *silicon diodes*. Measurements can be interpreted in terms of the energy that the radiation deposited throughout the human body or in a particular part of the body. When direct measurements are not possible (e.g., a radionuclide is deposited in an internal organ like the liver) the dose absorbed by that organ can be calculated provided that the amount of activity retained in the

organ is known. The amount of energy that ionizing radiation deposits in a unit mass of matter, such as human tissue, is called the *absorbed dose*. It is expressed in a unit called the rad, where 1 rad is equal to 100 erg[2] per gram. Submultiples of the rad are often used, such as the millirad (mrad), which is one-thousandth of a rad.

Types of ionizing radiation differ in the way in which they interact with biological materials, so that equal absorbed doses (meaning equal amounts of energy deposited) do not necessarily have equal biological effects. For instance, 1 rad to tissue from alpha radiation is more harmful than 1 rad from beta radiation because an alpha particle, being slower and more heavily charged, loses its energy much more densely along its path. In order to put all the different types of ionizing radiation on an equal basis with respect to their potential for causing harm, the quantity *equivalent dose* is used. It is expressed in a unit called the rem. Submultiples of the rem are commonly used, such as the millirem (mrem), which is one-thousandth of a rem. Equivalent dose is equal to the absorbed dose multiplied by a factor that takes into account the way in which a particular type of radiation distributes energy in tissue. For gamma rays, X rays, and beta particles, this radiation-weighting factor is set at 1, so the absorbed dose and equivalent dose are numerically equal. For alpha particles, the factor is set at 20, so that the equivalent dose is 20 times the absorbed dose. Values of the radiation weighting factor for neutrons of various energies range from 5 to 20. Equivalent dose accounts for differences in radiation effectiveness to cause biological harm. The equivalent dose provides an index of the likelihood of harm to a particular tissue or organ from exposure to various types of radiation regardless of their type or energy. Accordingly, 1 rem of alpha radiation to the lung, for example, would create the same risk of inducing fatal lung cancer as 1 rem of beta radiation (although the absorbed doses are very different).

Tissues and organs also vary in their sensitivity to radiation induced harm. For a given effective dose one tissue may be more sensitive than another. For example, the risk of fatal malignancy per unit equivalent dose is lower for the thyroid than for the lung. Moreover, there are other important types of harm such as non-fatal cancers or the risk of serious hereditary damage caused by irradiation of the testes or ovaries. These effects are different both in kind and in magnitude and we must take them into account when assessing the overall detriment to the health of human beings arising from exposure to radiation. Differences in tissue and organ radiosensitivity may be accounted for by taking the equivalent dose in each of the major tissues and organs of the body and multiplying it by a weighting factor related to the risk associated with that tissue or organ. The sum of these weighted

2. An erg is the metric unit of energy.

equivalent doses is a quantity called the *effective dose*. This quantity permits the various dose equivalents in the body to be represented as a single number. The effective dose also takes account of the energy and type of radiation, and therefore gives a broad indication of the detriment to health. Moreover, it applies equally to external and internal exposure and to uniform or non-uniform irradiation. It is common to abbreviate effective dose to *dose*.

It is sometimes useful to have a measure of the total radiation dose to groups of people or a whole population. The quantity used to express this total is the *collective effective dose* or just *collective dose*. It is obtained by adding, for all exposed people, the effective dose that each person in that group or population has received from the radiation source of interest. For example, in the United States the effective dose from all sources of radiation is, on average, 360 mrem (or 0.36 rem) in a year. Since the U.S. population is about 300 million, the annual collective effective dose to the whole U.S. population is the product of these two numbers, about 110 million *man rem*. The collective effective dose concept is very useful in describing trends in population exposures over time (e.g., doses to a worker population at a nuclear power plant over a 10 year period), and in comparing (population) exposures from different radiation sources. The concept however has its limitations. It should not be used to calculate probabilities of health effects in large populations from very small individual doses.

4.0 SOURCES OF RADIATION

Humans are exposed to radiation from outer space and from radionuclides in the Earth's crust. Radiation also comes from man-made sources. Natural sources of radiation, account for 82 percent of the radiation to which the public is exposed every year. There is no evidence of any increase in cancer among people living in areas where natural, background radiation is several times higher than average such as Han (China), Kerala (India) or Araxa-Tapira (Brazil).

The average American receives 360 mrem of radiation each year. Three hundred mrem come from natural sources: the sun's rays, rocks, soil, building materials and other background sources. The other 60 mrem come from human activities and products, like medical/dental X-rays and consumer products. According to the National Council on Radiation Protection and Measurements (NCRP),[3] an independent scientific body, the major sources of radiation exposure to the public are:

3. National Council on Radiation Protection and Measurements. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 93. Bethesda, MD: NCRP; 1987.

Natural Radiation: Radon in Indoor Air. Small amounts of radon-222, a radioactive gas, seep from uranium that is widely distributed in the Earth's crust. On average, radon trapped in homes accounts for 55 percent of the radiation to which Americans are exposed -- approximately 200 mrem every year.

Natural Radiation: The Human Body. About 11 percent of the average person's total exposure -- an average of 39 mrem per year -- comes from the human body itself. Potassium-40 and other radionuclides found in air, water and soil are incorporated into the food we eat, then into our bodies' own tissues.

Natural Radiation: Rocks and Soil. Rocks and soil account for about 8 percent of the public's exposure to radiation from all sources, or 28 mrem per year. The exposure comes from the Earth's crust and from building materials derived from soil and rocks. Brick and cinder-block homes expose the public to more radiation than do wooden homes. Granite used to build large structures, such as Grand Central Station in New York City, also exposes the public to small amounts of radiation.

Natural Radiation: Cosmic Rays. The average person receives about 8 percent of his total exposure -- 28 mrem per year -- from cosmic radiation from outer space. Actual exposures vary, since cosmic radiation increases with altitude, roughly doubling every 6,000 feet. A resident of Denver (one mile high) receives an average dose of about 50 mrem per year from cosmic radiation; those in Leadville, Colorado., at an altitude of two miles, get a cosmic ray dose of about 125 mrem per year; while a resident of Florida (at sea level) receives about 26 mrem per year from this source. Similarly, a passenger in a jet airliner at 37,000 feet (seven miles) may receive 60 times as much cosmic radiation in a given time as does someone at sea level.

Man-Made Radiation: Medical Procedures. The average American receives about 15 percent of his/her exposure to radiation from X-rays and nuclear medicine procedures -- an average of 45 mrem per year. A typical chest x-ray results in a 10 mrem dose. The contribution from medical sources is increasing rapidly. There were approximately 3 million CT examinations conducted yearly about 25 years ago; now (in 2007) about 60 million CT exams are performed per year. The NCRP is currently revising its estimate of the contribution of medical exposures and now

suggests that about 45% of a person's exposure to radiation is from medical sources.[4]

Man-Made Radiation: Consumer Products. The average American receives about 3 percent of his total exposure to radiation from consumer products, or approximately 9 mrem per year. Radon in natural gas used in cooking ranges contributes about five mrem per year. Smaller exposures can come from some smoke detectors, which use americium-241, and television sets. The use of lawn fertilizer can also expose an individual to radiation. Fertilizer contains potassium, of which a tiny amount is potassium-40, a naturally radioactive material.

Man-Made Radiation. Nuclear Power and Other Sources. Individuals are exposed to tiny amounts of radiation -- less than 1 percent of their total exposure -- from a variety of other activities. This includes radiation exposure from nuclear power plant operations, exposure due to fallout from past atmospheric testing of nuclear weapons, and from the generation of electricity from coal-fired and geothermal power plants.[5] Nuclear power plant operations do not expose people living near the plants to more than tiny amounts of radiation. Americans on average get less than 0.1 mrem from nuclear power plants per year. This includes radiation from storage of spent nuclear fuel. Extensive epidemiological studies of cancer in populations living near nuclear power plants indicate no long term effects that could be attributed to radiation exposure from nuclear plant operations.[6]

5.0 RADIOLOGICAL HEALTH EFFECTS

Scientists have studied the effects of radiation for more than 100 years, and they know a great deal about how to detect, monitor and control even the smallest amounts. In fact, more is known about the health effects of radiation than about most other physical or chemical agents.

5.1 Interactions of radiation with matter

Health effects of radiation exposure start with the deposition of radiation energy in cells, tissues and organs. When radiation passes through matter, it deposits energy in the material concerned. Alpha and beta particles, being electrically charged, deposit energy through *electrical interactions* with electrons in the material. Gamma

4. NCRP Scientific Committee 6-2 analysis of medical exposures. In: Advanced in Radiation Protection in Medicine, pp. 9-10, 43rd Annual meeting of the National Council on Radiation Protection and Measurements, Arlington, VA, April 16-17, 2007. Available at: http://www.ncrponline.org/Annual_Mtgs/2007_Ann_Meet_Prog.pdf
5. Coal-fired and geothermal power plants release radioactive material into the environment from naturally occurring radioactive materials.
6. Jablon, S. et al. *Cancer in Populations Living Near Nuclear Facilities*. NIH Publication 90-874. Washington, DC: U.S Government Printing Office; 1990.

rays and X rays lose energy in a variety of ways, but each involves liberating atomic (orbiting) electrons, which then deposit energy in interactions with other electrons. Neutrons also lose energy in various ways, the most important being through collisions with hydrogen atoms (a single proton in the nucleus). The protons are then set in motion and, being charged, they again deposit energy through electrical interactions. So in all cases, the radiation ultimately produces electrical interactions in the material.

The process by which a neutral atom or molecule becomes charged is called *ionization* and the resulting entity an *ion*. Once removed from an atom, an electron may in turn ionize other atoms or molecules. Any radiation that causes *ionization* — either directly, as with alpha and beta particles or indirectly as with gamma rays, X rays, and neutrons — is known as ionizing radiation.

It is the initial ionization and the resulting chemical changes that cause harmful biological effects. Radiation causes damage at the cellular level. Cells are the basic building blocks of all tissues and organs. When ionizing radiation traverses the cell, damage to a variety of molecules and cell structures may occur depending on the dose. A particularly important molecular target is DNA or deoxyribonucleic acid. This is the master molecule that controls all critical functions of the cell. Damage to DNA can result in death of the cell or mutations that can perturb cell functions.

A most important property of the various types of ionizing radiation is their ability to penetrate matter. The depth of penetration for a particular type of radiation increases with its energy, but varies from one type of radiation to another for the same amount of energy. With charged particles such as alpha and beta particles, the depth of penetration also depends on the mass of the particle and its charge. For equal energies, a beta particle will penetrate to a much greater depth than an alpha particle. Alpha particles can scarcely penetrate the dead, outer layer of human skin; consequently, radionuclides that emit them are not hazardous unless they are taken into the body through breathing or eating or through a skin wound. Beta particles penetrate about a centimeter of tissue, so radionuclides that emit them are hazardous to superficial tissues, but not to internal organs unless they too are taken into the body. For gamma rays and neutrons, the degree of penetration depends on the nature of their interactions with tissue. Gamma rays can pass through the body, so radionuclides that emit them may be hazardous whether on the outside or the inside. X rays and neutrons can also pass through the body.

5.2 High dose effects

Biological effects of radiation at high dose are primarily the result of cell killing in the irradiated tissues or organs. Cells are killed because of extensive, irreparable

damage to the DNA and other critical cell components. Extensive cell killing as a result of radiation exposure may result in observable changes in the irradiated tissue within days or weeks of exposure. Such damage is referred to as acute effects. Radiation doses of different sizes, delivered at different rates to different parts of the body, can cause different types of health effect at different times. Very high doses to the *whole body* can cause death within weeks. For example, an absorbed dose of 500 rad or more received instantaneously would probably be lethal, unless treatment was given, because of damage to the bone marrow and the gastro-intestinal tract. Appropriate medical treatment may save the life of a person exposed to 500 rad, but a whole body dose of 5,000 rad or more would certainly be fatal even with medical attention. A very high dose to a *limited area* of the body might not prove fatal, but other early effects could occur. For example, an instantaneous absorbed dose of 500 rad to the skin would cause erythema (i.e. painful reddening of the skin) within a week or so, whereas a similar dose to the reproductive organs might cause sterility. These types of effects are called *deterministic effects* because they occur only if the dose or dose rate is greater than some threshold value (usually in excess of 50 rad delivered in a short period of time), and the effect occurs earlier and is more severe as the dose and dose rate increase. In radiotherapy for the treatment of cancer, a very high dose of radiation is spread over several weeks to the specific area of the body containing the tumor. Doses and the area of the body to be treated are tightly controlled to eradicate the tumor and minimize damage to surrounding healthy tissue.

5.3 Low dose effects-cancer and genetic effects

If the dose is lower, or is delivered over a longer period of time, there is a greater opportunity for the body cells to repair the damage, and there may be no early signs of injury. Even so, tissues may still have been damaged in such a way that effects appear much later in life (perhaps decades). These types of effect are called *stochastic effects*. They are not certain to occur, but the likelihood that they will occur increases as the dose increases. Because radiation is not the only known cause of most of these effects, it is normally impossible to determine clinically whether an individual case is the result of radiation exposure or not.

The most important stochastic effect is *cancer*, which is always serious and often fatal (depending on the type of cancer). Although the exact cause of most cancers remains unknown or poorly understood exposure to agents such as tobacco smoke, asbestos, ultraviolet radiation, and ionizing radiation are known to play a role in inducing certain types of cancer. The development of cancer is a complex, multistage process that usually takes many years. Radiation appears to act principally at the initiation stage, by introducing certain mutations in the DNA of

normal cells. These mutations do not kill the cell but allow it to enter a pathway of abnormal growth that can sometimes lead to the development of a malignancy.

Ionizing radiation is known to cause many different types of cancer. Major cancers that have been observed include cancer of the breast, lung cancer, thyroid cancer and leukemia (cancer of the bone marrow). Not all cancers are fatal. Some cancers like thyroid cancer have a high survival probability (90% or more); other cancers like lung cancer are associated with poor survival (about 10%). In radiological protection the risk of fatal cancer is of primary concern because of its extreme significance. The use of fatal cancer risks also makes it easier to compare them with the other fatal risks encountered in life.

5.4 Risks of cancer

Given that we cannot distinguish between those cancer cases resulting from radiation exposure and those with other causes, how can the risk of cancer be determined? In practice health risks are estimated by conducting epidemiological studies (an observational science concerned with the distribution of diseases in a population and their causes) of specific diseases in specific population groups. Suppose that the number of people in an irradiated group and the doses they have received are known. By observing the occurrence of cancer in the group and comparing with the number of cancers expected in an otherwise similar but unirradiated group, the increased risk of cancer per unit dose can be estimated. It is most important to include data for large groups of people in these calculations so as to minimize the statistical uncertainties in the estimates and take account of factors, such as age and gender that affect the spontaneous development of cancer.

The main sources of information on the additional risk of cancer following exposure of the whole body to gamma radiation are studies of the survivors of the atomic bombs dropped on Hiroshima and Nagasaki in 1945. Various occupational and medical exposure situations (including radiation treatments for non-cancerous diseases) have also provided important information in support of the atomic bomb-derived risk estimates.[7] Authoritative bodies such as the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCREAR), the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and the National Research Council's Biological Effects of Ionizing Radiation (BEIR) Committees periodically

7. For a summary of many epidemiological studies see United Nations Scientific Committee on the Effects of Atomic Radiation. *Sources and Effects of Ionizing Radiation*. Volume II: Effects. UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes. New York: United Nations; 2000; National Research Council, *Health Risks from Exposure to Low Levels of Ionizing Radiation*. BEIR VII Report. Washington, DC: The National Academies Press; 2005.

review published epidemiological and scientific data for the purposes of refining cancer risk estimates.

Most of the Japanese atomic bomb survivors and other exposed groups studied received high doses over short periods of time. Observations of the cancer incidence in these groups, along with estimates of the doses they received, indicate that, for high doses and high dose rates, there is a linear relationship between dose and risk. Thus, for example, doubling the dose would double the risk. However, most radiation exposure, particularly in the nuclear industry, involves low doses delivered over long periods.

At these low levels of exposure, studies of cancer incidence in the exposed population do not provide any direct evidence about the relationship between dose and risk, because the number of extra cancers that might be expected to result from the radiation exposure is too small (compared to the total number of cancer cases in the population from all causes) to detect. It is, therefore, necessary to consider other scientific information about the effects of radiation on cells and organisms and to form a judgment as to the most likely form of the dose–risk relationship. For many years, the internationally accepted solution has been to assume that the relationship is linear for low doses, all the way down to zero (known as the 'linear–no threshold' or LNT theory), i.e. that any radiation dose has a potential detrimental effect, however small. But, some recent radiobiological experiments have been interpreted as suggesting that low doses of radiation have no detrimental effect, because the body can successfully repair all of the damage caused by the radiation, or even that low doses of radiation may stimulate the repair mechanisms in cells to such an extent that they actually help to prevent cancer. Other experiments have been used as the basis for theories that low doses of radiation are more harmful (per unit of dose) than high doses, or that the hereditary effects of radiation could get worse from generation to generation.

After a major review of biological effects at low doses of ionizing radiation, UNSCEAR concluded in 2000 that "…an increase in the risk of cancer proportionate to radiation dose is consistent with developing knowledge and it remains, accordingly, the most scientifically defensible approximation of low dose response." However, UNSCEAR also accepted that there are uncertainties and stated that "… a strictly linear dose response relationship should not be expected in all circumstances."[8]

8. United Nations Scientific Committee on the Effects of Atomic Radiation. *Sources and Effects of Ionizing Radiation.* Volume II: Effects. UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes. New York: United Nations; 2000

In reality, the risk to an actual person from a given dose will depend on that person's age at the time of the exposure and on their gender. For example: if a person receives a dose late in life, a radiation-induced cancer may not have time to appear before the person dies of another cause; and the risk of breast cancer is virtually zero for men. Furthermore, recent scientific advances indicate that a person's genetic constitution can influence their risk of cancer after irradiation. At present, we can identify only rare families who may carry increased risk, but experts may in the future be able to take some account of such inherited traits in predicting radiation risks.

Risk factors are also different for different populations. This is partly because different populations have different distributions of ages and different natural incidences of disease. For example, since the average age of a population of workers is generally higher (and therefore their life expectancy is shorter) than that of the population as a whole, the risk factor for workers is lower than the risks in the general population.

An important consequence of the assumption that risk is proportional to dose, without a threshold, is that the collective effective dose becomes an indicator of communal harm. Under this concept it makes no difference mathematically whether, in a community of 50,000 people, each receives an effective dose of 200 mrem, or in a community of 20,000 people, each receives 500 mrem; the collective dose in each community is 10,000 person-rem, and the communal cost in each community would be expected to be the same. However, members of the smaller community run the greater individual risk of fatal cancer. As indicated in Section 3.0 "Radiation Quantities and Units," calculations of collective dose for the purposes of predicting public health effects should not be taken too far: the product of a very large number of people and a very small dose is likely to be meaningless.

6.0 RADIOLOGICAL PROTECTION

Radiation exposures particularly from man-made sources are strictly controlled so as to avoid deterministic effects and to keep the probability of stochastic effects as low as possible. The current system of radiation protection in place in the U.S. and many other countries is based on three fundamental principles. Each of these is based on an in depth scientific understanding of radiation and radiological health effects but there are also social issues involved that require a considerable need for the use of professional and policy judgment.

6.1 Justification of a practice

No practice involving exposure to radiation should be adopted unless it produces at least sufficient benefit to the exposed individuals or to society to offset the radiation detriment it might cause. Nuclear power generation provides tremendous benefits for society and to the workers who operate the plants. Although the costs of generating electricity, complying with regulations, and otherwise maintaining a safe work environment are high, the benefits to society outweigh the risks. In diagnostic medicine, patients are routinely given small doses of radiation in the process of diagnosing or ruling out certain diseases. The benefits for the patient almost always outweigh the usually small risks of exposure. However, when there is no benefit to be gained by the proposed activity, even a small radiological risk would negate justification of a practice. For example use of diagnostic ultrasound *only* to determine the sex of an unborn child carries no benefit for the mother or the child. This practice is not justified even though ultrasound risks are small.

6.2 Optimization of protection (ALARA)

In relation to any particular source of radiation within a practice, the dose to any individual from that source should be below an appropriate dose constraint, and all reasonable steps should be taken to adjust the protection so that exposures are ALARA (as low as reasonably achievable), economic and social factors being taken into account.

Since we assume that no radiation dose is entirely free from risk, it is important to pay attention to all doses and to reduce them whenever it is reasonably achievable. Eventually the point must come when further reductions in dose become unreasonable, because social and economic costs would outweigh the value of the reductions. Any residual risk as a consequence of an ALARA program would be considered acceptable (otherwise additional resources would be allocated to reduce dose further) and protection would then be considered optimized.

The key to an effective ALARA program is identifying what is "reasonable" in terms of costs and benefits Unfortunately there is no clear decision rule that can be applied across all radiological environments. What may be reasonable and acceptable in one setting may not be in another because of differences in cost constraints and site-specific requirements.

6.3 Application of individual dose limits

The third principle establishes dose limits for individuals and populations.[9] For a practice that is justified there is an obligation not to expose individuals to an unacceptable risk. This is accomplished by imposing strict dose limits and applying

9. Radiation exposure for the purposes of medical diagnosis and therapy are excluded from dose constraints.

the principle of optimization of protection to keep doses ALARA. In the U.S. dose limits are set by several federal agencies. For nuclear power plant operations, the U.S. Nuclear Regulatory Commission sets standards and dose limits. In the U.S., nuclear workers are limited to 5000 mrem per year to the whole body. The public is limited to an annual exposure of 100 mrem from all sources (25 mrem per year from any single source). These prime limits, expressed in terms of effective dose, are intended to control the incidence of serious effects such as cancer that involve an element of probability. The limits are set far below doses that produce observable health effects.

The U.S. dose limits reflect the prevailing assumption among government (and industry and many academic) authorities that an individual must receive a whole-body dose of about 25,000 mrem (15,000 mrem for a pregnant woman) before there is a significant increase in the risk of serious human health effects, and a dose of about 500,000 mrem (500 rem) before probable death as a result of radiological health effects. The ALARA objective is to maintain worker and public doses as far below the applicable limits as reasonably achievable given social, technical, economic and policy considerations. The ALARA concept recognizes the uncertainties associated with the risk of low level exposure to ionizing radiation. Coupled with this uncertainty is considerable technical controversy about the magnitude of the probability of individual health effects as a result of any additional exposures above background levels.

There are two common misconceptions about dose limits. The first is that they mark an abrupt change in biological risk, a line of demarcation between safe and unsafe. It should be clear from the discussion on dose and risk that this is not so. This is also apparent from the fact that there are different dose limits for workers and members of the public. These limits differ because higher risks are deemed more acceptable for workers, who receive a benefit from their employment, than for members of the public, whose risk is involuntary. The second misconception is that keeping doses below the limits is the only important requirement in radiological protection. On the contrary, the overriding requirement is to keep doses as low as reasonably achievable. This is reflected in the increasing emphasis on investigation levels, which are, of course, set below dose limits.

7.0 PUBLIC PERCEPTIONS OF RISK

The greatest concern about ionizing radiation stems from its potential to cause malignant diseases in exposed persons. The likelihood of such effects depends on the amount of radiation that a person receives, whether from a natural or an artificial source. As the effects of ionizing radiation have become better understood

during recent decades, a system for radiological protection has been developed to protect people from exposure to sources of radiation. But public anxiety remains.

Radiation is one cause, among many, of the 'dread disease' cancer. Our senses cannot detect radiation, making this invisible risk seem even more insidious. Our collective anxiety is strengthened by memories of accidents at nuclear power plants and other facilities, and by the common tendency to associate any form of radiation with all things 'nuclear', including nuclear weapons. Another contributory reason for general heightened sense of concern about radiation may be the lack of reliable and accessible information and the misunderstandings that arise. Efforts to inform the public through public information campaigns can go a long way to address many concepts and facts about radiation and radiation safety that have been chronically misunderstood.

PRAIRIE ISLAND ISFSI RISK ASSESSMENT

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0.0 SUMMARY

The Prairie Island Nuclear Generating Plant operates an Independent Spent Fuel Storage Installation (ISFSI) located on the plant site. Plant personnel receive an average annual dose of 4.6 mrem from the ISFSI; members of the public located at the nearest residence receive an annual dose less than 1.0 mrem from operation of the ISFSI. These doses are so low that they are well within the variation of natural background levels across the State of Minnesota. Annual doses from the ISFSI to plant workers are less than 2% of natural background radiation levels; annual doses to the general public are less than 1% of natural background. Average worker doses are 1000 times lower than federal occupational exposure limits. Doses to the public are 100 times lower than applicable public dose limits as established by the U.S. Nuclear Regulatory Commission.

Health risks (as measured by cancer mortality) from radiation exposure to workers and the public cannot be measured directly because doses are so low. Public health impacts must be determined theoretically. Assuming a worker population of 1000, less than one additional cancer death due to radiation exposure would be expected in the next 70 years as a result of ISFSI operations. In comparison, about 200 cancer deaths would be expected in this population from all causes of cancer. Similarly, no additional cancer deaths due to radiation exposure would be expected among members of the public living in the vicinity of the plant. Assuming a population of 400 persons, 80 individuals would be expected to die of cancer from all causes.

Based on current dose estimates, ISFSI operations do not pose a health threat to either workers or members of the general public.

1.0 INTRODUCTION

Prairie Island Nuclear Generating Plant (PINGP) is located in Goodhue County, Minnesota on the banks of the Mississippi River. The plant has two 575 MWe pressurized water reactors. Unit 1 began commercial operations at full power in 1973; Unit II did so in 1974. PINGP is owned by Xcel Energy Corporation and operated by Nuclear Management Company, LLC. The US Nuclear Regulatory Commission licensed an Independent Spent Fuel Storage Installation (ISFSI) to PINGP in 1993. The plant began storing spent fuel at the Installation in 1995. The ISFSI is located within the owner controlled area, in the southwestern sector of the plant site.

This report is a health risk assessment for the ISFSI at PINGP. It is part of Nuclear Management Company's petition to the State of Minnesota to increase storage capacity of spent nuclear fuel at the ISFSI. Dry cask storage of spent nuclear fuel can result in radiation exposure of workers and the public due to penetrating gamma and neutron radiation from the radioactive decay of spent nuclear fuel. Doses from inhalation of radionuclides or immersion in a radioactive plume as a result of leakage of canisters are assumed to be zero. Canisters are designed and tested to be leak tight. Thus, leakage is not considered to be a credible accident scenario.

For the purposes of radiological risk assessment and management it is assumed that any radiation dose, no matter how small may increase the risk of cancer.[1] This risk assessment is based on doses to workers and the public reported in the PINGP Safety Analysis Report and updated public doses provided by .[2]

1.1 Purpose of risk assessment

The purpose of risk assessment is to provide pertinent information on populations at risk, exposure patterns, radiation doses, types of health effects and probabilities of health effects to risk managers, policy makers and regulators so that the best possible decisions can be made regarding management of the risk. Risk assessment does not measure the *real* health effects that exposure to a hazardous agent may have on a population. Risk assessments may be conducted without considering what the actual exposures may be to a population considered at risk. Risk assessment particularly involving very small exposures to hazardous agents have a high degree of uncertainty but conservative safety margins are built into an assessment analysis to ensure protection of the public.

Exposure to ionizing radiation has been well characterized. Ionizing radiation can be easily measured and sources of natural background radiation are well known. The major source of ionizing radiation to human populations is inhalation of radon gas accounting for about half of the total exposure (Table 1).[3] The table excludes contributions from medical exposures. When the risk assessment exercise involves very small doses of ionizing radiation, as in the present risk assessment, the contribution of the natural background becomes important in assessing overall risk and putting the additional radiation doses into appropriate perspective. Humans are exposed primarily from natural sources; non-medical anthropogenic exposures

1. Only cancer mortality risks are considered in this study. National Council on Radiation Protection and Measurements, *Risk Estimates for Radiation Protection*. NCRP Report No. 115. Bethesda, MD: NCRP; 1993.
2. Prairie Island Independent Spent Fuel Installation Safety Analysis Report, Section 7; Memo on public dose rates from Oley Nelson, PINGP to Kenneth Mossman May 30, 2007.

including exposure from the nuclear fuel cycle (of which storage of spent nuclear fuel is an end stage) provide very little additional exposure.[3]

Regulations to limit environmental and occupational exposures to ionizing radiation are based on the assumption that any dose, no matter how small, might cause cancer and that the relation between dose and cancer induction is linear. The biological assumptions underlying the linear, no-threshold (LNT) theory are now seriously questioned. There is now clear evidence that other biologically plausible theories are more appropriate for some tumors and carcinogens. Many scientists now believe that LNT-derived risks overestimate true risks in the low dose range.[4]

Risks are determined in a relatively straightforward manner by multiplying the dose by the LNT-derived risk coefficient. This is a conservative approach to risk assessment since direct observations of adverse health effects have not been observed in the dose range of interest in this report. As the final step in the risk assessment process, risk characterization must include careful consideration of uncertainties in risk. To do otherwise would imply that risks are known with a degree of certainty that is not borne out by the data.

Table 1. Sources of human exposure to ionizing radiation

Average worldwide exposure to radiation (excluding medical exposure)

	Annual effective dose (mSv)	
Source	Average	Typical range
Cosmic rays	0.39	0.3-1.0
External terrestrial	0.48	0.3-0.6
Inhalation (mainly radon)	1.15	0.2-10
Ingestion	0.29	0.2-0.8
Man-made	Very small	
Total	2.4	1-10

3. United Nations Scientific Committee on the Effects of Atomic Radiation. *Sources and Effects of Ionizing Radiation.* Volume I: Sources. UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes. New York: United Nations; 2000

4. Mossman, KL. *Radiation Risks in Perspective*. Boca Raton, FL: Taylor and Francis Publishers; 2006.

2.0 DOSES TO WORKERS AND THE PUBLIC FROM DRY CASK STORAGE

Dose assessment is important for several reasons. Dose measurements are necessary in order to make decisions on siting of the ISFSI arrays within PINGP. The arrays must be sited such that the annual dose equivalents to individuals located beyond the controlled area does not exceed 25 mrem. Dose estimation is also important in the risk assessment process. The dose estimates used in this report are based on the assumption that there is no canister leakage that would contribute to dose and that ISFSI doses are due to gamma rays and neutrons from stored spent nuclear fuel.[5]

2.1 Radionuclides contributing to dose

Spent nuclear fuel contains a number of biologically important radionuclides (Table 2). Radionuclides emitting gamma rays are particularly important because the radiation is highly penetrating and depending on the amount of shielding some fraction can escape containment and expose workers and the general public. Gamma ray dose decreases exponentially with increased shielding thickness. Radionuclides that emit alpha (α) and beta (β) radiation do not pose an external hazard because the radiation cannot penetrate the canister or ISFSI shielding. However, these radionuclides are a potential health hazard if contacted directly through inhalation, ingestion or skin contact. Neutrons can also be generated due to the interaction of high energy alpha radiation with surrounding material. For instance a mixture of Am-241 alpha rays and beryllium emits neutrons. Like gamma rays, neutrons can be highly penetrating and may expose individuals at a distance from the spent nuclear fuel elements.

The highest energy gamma radiation is emitted by Cs-137. It has a short half-life relative to other biologically important radionuclides (Table 2). In consideration of permanent disposal the concern is with the radiation emissions from the very long-lived transuranics (Table 2). These radionuclides emit relatively low energy gamma radiation. Thus the radiological hazard associated with gamma radiation emission would decrease significantly over several decades due to the decay of Cs-137. Radionuclides that emit gamma radiation do not constitute that portion of spent fuel which is of greatest concern with respect to storage of spent fuel over a long duration of time.

5. *Supra* note 2.

Table 2. Biologically Significant Long-Lived Radioisotopes in Commercial Spent Fuel

RADIONUCLIDE	HALF –LIFE	PRINCIPAL RADIATION EMISSIONS
Strontium-90/Yttrium-90	28.5 y	β^-, γ
Technetium-99	213,000 y	β^-
Cesium-137	30.2 y	β^-, γ
Neptunium-237	2,140,000 y	α, γ
Plutonium-238	87.7 y	α, γ
Plutonium-239	24,131 y	α
Plutonium-241	14.4 y	β^-
Americium-241	432 y	α, γ

2.2 Dose estimates

The following dose estimates were derived from the Prairie Island Independent Spent Fuel Installation Safety Analysis Report, Section 7 and from public dose rate data provided in a memo from Oley Nelson (Dry Cask Project Engineer, PINGP) to Kenneth Mossman dated May 30, 2007. Doses in mrem are due to gamma ray and neutron exposure from radionuclide decay of spent nuclear fuel, and refer to exposure of the whole body (and maximally exposed organ). Dose estimates are conservative and assume a 2500 hour-year for full-time employees; a 540 hour-year for outage employees, a 400 hour-year for summer help and a 8760 hour- year for calculation of annual public doses.

The annual dose to workers shown in Table 3 represents the weighted average dose to all full-time, outage and summer employees in 13 plant building locations. The highest doses were to workers in the Construction Warehouse and the NPD Annex Building. The dose rate to a member of the public living at the nearest residence is assumed to be 1 mrem per year from decay of radioactive material in spent nuclear fuel. The nearest residence is estimated to be 700 meters (0.45 miles) from the ISFSI arrays in the northwest direction. This is a very conservative estimate of dose rate; direct estimates of dose rate at 700 meters from the ISFSI (in the direction of the nearest residence) is 0.36 ± 0.18 mrem/year; at 600 meters the dose rate is 0.77 ±0.11 mrem/year.[6]

6. *Supra* note 2.

Table 3. Estimated doses to workers and the general public from ISFSI arrays

GROUP	ANNUAL DOSE	ANNUAL NATURAL BACKGROUND LEVEL
Workers: Plant Personnel	4.6 mrem	240 mrem (100-1000)
Public: Nearest Residence	1.0 mrem	

Both occupational and public dose estimates are well within applicable federal regulatory limits. The annual dose limit for workers in 5000 mrem; the annual public dose limit from all sources of exposure excluding medical applications is 100 mrem. The nearest real resident cannot receive a dose in excess of 25 mrem per year (as a single source of exposure) and assumes that individuals may be exposed to other sources of radiation that, when summed, do not exceed the 100 mrem limit.[7]

2.3 Dose comparison with natural background radiation levels

Worker and public dose estimates are well within world-wide annual average natural background radiation levels of 200-300 mrem (Table 2; 1 mSv = 100 mrem). Natural background levels around the world range from about 100 mrem per year to about 1000 mrem per year. In fact the estimated doses from the ISFSI array are so small that they are well within local variations in natural background levels. Differences in natural background radiation levels in Minnesota exceed the dose estimates in Table 3 for the ISFSI array.[8]

The average American receives about 300 millirem annually from natural sources including the sun's rays, rocks, soil, building materials and other background sources. According to the National Council on Radiation Protection and Measurements,[9] an independent scientific body, the major sources of natural radiation exposure to the public are:

7. Dose limits for radiation workers may be found at 10 CFR 20; dose limits for members of the general public may be found at 10 CFR 72.104.
8. Natural background radiation levels vary across the State of Minnesota. The major source of variability is radon concentration. See http://www.epa.gov/radon/zonemap/minnesota.htm
9. National Council on Radiation Protection and Measurements. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 93. Bethesda, MD: NCRP; 1987.

Radon in Indoor Air. Small amounts of radon-222, a radioactive gas, seep from uranium that is widely distributed in the Earth's crust. On average, radon trapped in homes accounts for 55 percent of the radiation to which Americans are exposed -- approximately 200 millirem every year.

The Human Body. About 11 percent of the average person's total exposure -- an average of 39 millirem per year -- comes from the human body itself. Potassium-40 and other radionuclides found in air, water and soil are incorporated into the food we eat, then into our bodies' own tissues.

Rocks and Soil. Rocks and soil account for about 8 percent of the public's exposure to radiation from all sources, or 28 millirem per year. The exposure comes from the Earth's crust and from building materials derived from soil and rocks. Brick and cinder-block homes expose the public to more radiation than do wooden homes. Granite used to build large structures, such as Grand Central Station in New York City, also exposes the public to small amounts of radiation.

Cosmic Rays. The average person receives about 8 percent of his total exposure -- 28 millirem per year -- from cosmic radiation from outer space. Actual exposures vary, since cosmic radiation increases with altitude, roughly doubling every 6,000 feet. A resident of Denver (one mile high) receives an average dose of about 50 millirem per year from cosmic radiation; those in Leadville, Colorado., at an altitude of two miles, get a cosmic ray dose of about 125 millirem per year; while a resident of Florida (at sea level) receives about 26 millirem per year from this source. Similarly, a passenger in a jet airliner at 37,000 feet (seven miles) may receive 60 times as much cosmic radiation in a given time as does someone at sea level.

The estimate doses from the ISFSI arrays are only a tiny fraction of the dose attributable to any single component of the natural background.

3.0 HEALTH EFFECTS FROM SMALL DOSES OF IONIZING RADIATION

The principal health effect of concern following exposure to small doses of ionizing radiation is cancer induction. Ionizing radiation at high dose (above about 10,000 mrem) is a known human carcinogen. Numerous population studies involving military, medical, and occupational uses of radiation clearly show that leukemia and a variety of solid tumors may be induced by radiation. However at low doses of radiation (e.g., the dose estimates under consideration in this risk assessment) the evidence for cancer causation is much less compelling. Most low

dose epidemiological studies show no consistent health effects. Only a few studies suggest a significant association between radiation and cancer. However, even in these investigations, the causal nature of such associations and the levels of risk remain highly uncertain.[10]

Radiation risks for cancer have been based primarily on studies of Japanese survivors of the atomic bombings.[11] Excess cancers have been observed in the Japanese cohort that received doses above 20,000 mrem. Below this dose, radiogenic cancers are proportionally lower in number and have been very difficult to detect. Extrapolation of data derived from the "high" dose cohort, using the LNT theory, has been the basis for predicting cancer risk at low doses.

The four major cancer types identified in the Japanese survivors are: leukemia, lung cancer, female breast cancer and cancer of the thyroid gland. The first cancer reported was leukemia which began to appear in the exposed Japanese population a few years after the bombing. However, not all leukemia types were equally affected. Acute leukemia and chronic granulocytic leukemia were substantially increased in the exposed populations but chronic lymphocytic leukemia incidence remained unchanged in survivors. Radiation-induced solid cancers became apparent 5 to 10 years (at a minimum) after leukemia induction. Only after 1974 did the cumulative excess of solid cancers since 1950 exceed the leukemia excess. Cancers of the esophagus, stomach, urinary tract and lymphomas have also been observed in excess in the Japanese survivor studies.[12]

The Hiroshima and Nagasaki experience has formed the basis for an extensive human data base which has been used in the development of radiation risk estimates and radiation protection standards. Supplementing the atomic bomb survivor data are a large number of smaller epidemiological studies involving medical uses of radiation.[13]

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10. United Nations Scientific Committee on the Effects of Atomic Radiation. *Sources and Effects of Ionizing Radiation.* Volume II: Effects. UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes. New York: United Nations; 2000

11. The largest single source of radiogenic cancer risk data is the survivors of the atomic bombings of Hiroshima and Nagasaki in August, 1945. In the Life Span Study (one of several cohort-based epidemiological studies), conducted by the Radiation Effects Research Foundation, approximately 86,000 atomic bomb survivors are being studied with mortality and causes of death continuously updated. Individuals received doses ranging from less than 10,000 mrem to more than 500,000 mrem. The average dose to survivors was approximately 20,000 mrem. Over 6,000 cancer deaths have been observed; only about 400 of these cancers might attributable to radiation exposure. See Preston, D.L. et al., Studies of mortality of atomic bomb survivors, Report 13: Solid cancer and non-cancer mortality 1950-1997. *Radiation Research* **160:** 381-407 (2003).

12. National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiation.* BEIR V Report. Washington, DC: National Academy Press; 1990; National Research Council, *Health Risks from Exposure to Low Levels of Ionizing Radiation.* BEIR VII Report. Washington, DC: The National Academies Press; 2005.

13. *Ibid.*

4.0 RISK ESTIMATION

Based on the dose estimates presented in Section 2.0, radiogenic cancer risks to workers and the public can be determined. The calculation is straightforward and is simply the product of the dose and risk coefficient (i.e., lifetime risk of cancer per unit radiation
dose). Several authoritative bodies have estimated cancer risks for use in radiation

protection.[14] For the purposes of this risk assessment the following nominal lifetime excess cancer risk coefficients have been assumed:

5.0×10^{-7} lifetime fatal cancers per mrem for members of the public

The nominal risk to the general public is 25% higher than the worker risk because the general population includes males and females of all ages (children are more sensitive than adults). Worker populations are predominantly male between the ages of 20 and 70. Thus, worker populations exclude women and children that contribute to the collective sensitivity of the population. For purposes of this report worker risks are considered equivalent to public risks. This assumption results in a conservative estimate of harm in the worker population.

As discussed more completely in section 5.0 (Risk Assumptions and Uncertainties), risk estimates should be viewed as subject to many uncertainties including epidemiological limitations, risk extrapolation from high dose to low dose and extrapolating risks from high dose rate to low dose rate. Although risk coefficients appear to be highly quantitative and better defined than risks for most other carcinogens, there is a need to carefully interpret risk assessments based on these risk coefficients.

This risk assessment examines cancer mortality risks in the following populations:[15]

1. plant personnel: N = 923
2. members of the public residing at the nearest residence: N = 414

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14. The International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements have general agreement on the magnitude of radiogenic cancer risks (see National Council on Radiation Protection and Measurements. *Limitation of Exposure to Ionizing Radiation*. NCRP Report No. 115. Bethesda, MD: NCRP; 1993. The U.S. National Research Council BEIR Committees also analyses scientific data and publishes risk estimates that are in general agreement with the ICRP and NCRP estimates. The risk estimates used in this report are taken from NCRP Report No. 115.
15. *Supra* note 2.

4.1 Health risks to plant personnel

A nuclear worker on the plant site may be exposed to ionizing radiation from the ISFSI arrays. Table 4 provides estimates of risk assuming that all workers receive a weighted average dose of 4.6 mrem per year. Some workers will receive more or less depending on their employment status (full-time, outage, summer employment) and their work location. Table 4 provides estimates of risk in terms of probabilities and cancer mortality rates per 10,000 population over exposure periods ranging from 1 to 70 years. The highest risks are for workers exposed for a 70 year period (an unrealistic time frame if one assumes that work begins at age 20). Nevertheless no excess cancer deaths would be expected even for 70 years of employment given that there are fewer than 1000 persons employed at the plant. By comparison 20 percent of the worker population would be expected to die from cancer from all cancer causes.[16]

4.2 Health risks to members of the public at nearest residence

A member of the public located in a house about 0.45 miles northwest of the plant may be exposed to ionizing radiation from the ISFSI arrays. For the purposes of this risk assessment it is assumed that residents receive 1.0 mrem year with no air or building shielding. Table 4 provides estimates of risks (in terms of probabilities) and mortality rates (in terms of cancer deaths per 10,000 population) and are calculated for different exposure periods (1-70 years). No excess cancer deaths would be expected even if exposure were for a 70 year period since there are fewer than 500 persons residing in the immediate vicinity of the plant. By comparison about 100 persons in this population would be expected to die of cancer from all causes of cancer.[17]

4.3 Brief risk analysis

Numbers in Table 4 have been rounded to facilitate analysis and presentation. Because the doses are so small, the associated risks for cancer are also small and impossible to measure directly. The probabilities and the respective mortality rates (cancer deaths per 10,000) are equivalent expressions of risk. But the mortality rate may be easier to comprehend. For comparative purposes and to put the radiological risks into perspective, the probability of death from cancer and the resulting number of cancer deaths in a population of 10,000 persons are shown. The reference population size of 10,000 is arbitrary and is used to facilitate comparisons of estimated health effects over various time periods (Table 4). In fact, the actual population that lives in the immediate vicinity of the plant is estimated to be closer to 400. Clearly, if no health effects (even for a 70-year

16. American Cancer Society, *Cancer Facts & Figures 2007*. Atlanta GA: American Cancer Society Inc. 2007.
17. *Ibid.*

exposure) are expected among 10,000 persons, there will be no health effects in a population that is 25 times smaller. The number of radiogenic cancers from a 70-year exposure is minuscule compared to the total mortality cancer burden in the population from all causes of cancer that are expected in the absence of radiation exposure from the ISFSI. In a population of 10,000 persons, 2,000 would be expected to die of cancer from all causes (e.g., smoking) excluding ISFSI radiation. Likewise, in a population of 400 persons, 80 would be expected to die of cancer. Similar comparisons can be made regarding the worker population (about 900 full-time employees, outage workers and summer help).

Table 4. Cancer mortality risks to workers and members of the public

INTEGRATED RISK	Workers: Lifetime Cancer Mortality Risk	Workers: Excess cancer deaths per 10,000	Public: Lifetime Cancer Mortality Risk at nearest residence	Public: Excess cancer deaths per 10,000 at nearest residence
1 year	1/430,000	0.0 (0-0)	1/2,000,000	0.0 (0-0)
10 years	1/43,000	0.2 (0-0.4)	1/200,000	0.1 (0-0.1)
20 years	1/21,000	0.5 (0-1)	1/100,000	0.1 (0-0.2)
50 years	1/8,000	1.2 (0-2)	1/40,000	0.3 (0-0.5)
70 years	1/6,000	1.6 (0-3)	1/28,000	0.4 (0-0.7)
cancer deaths/ no radiation	1/5	2,000	1/5	2,000

Calculations of risks for 10, 20, 50 and 70 year periods simply assumed that the total dose was delivered all at once. This assumption introduces significant conservatism in the risk calculation because no accounting is made for repair of radiation damage when the dose is actually delivered at a uniform rate over the time period of interest. An instantaneous dose of 70,000 mrem would be more biologically effective than the same dose delivered uniformly over a 70 year period.

Mortality rates are also expressed as a range of possible values (numbers shown in parentheses in Table 4) based on an uncertainty analysis of lifetime cancer mortality risk estimates.[18] Because of the uncertainties in risk at doses approximating natural

18. National Council on Radiation Protection and Measurements. *Uncertainties in Fatal Cancer Risk Estimates Used in Radiation Protection*. NCRP Report No. 126. Bethesda, MD: NCRP; 1997.

background radiation levels, the lower value of the range is zero.[19] The most probable outcome is no increase in cancer deaths as a result of radiation exposure. It should be emphasized that the possibility of health effects at small doses cannot be totally discounted. However, if there is a risk it is so small that it cannot be measured reliably.

A (theoretical) person who lived continuously at the nearest residence for 70 years would have about a 1 in 28,000 chance of dying of cancer because of radiation exposure from the spent nuclear fuel stored at the ISFSI array. However, this same person's chance of dying of cancer without PINGP radiation exposure is about 1 in 5 (i.e., a risk that is 5600 times higher than the radiation risk). The additional risk from radiation exposure from PINGP cannot be detected because of the large number of cancer deaths that will occur because of other causes unrelated to radiation exposure.

5.0 RISK ASSUMPTIONS AND UNCERTAINTIES

A number of key principles have emerged in the study of cancer in exposed human populations that bear on interpretation of risk assessment data:

- Cancer is a very common collection of diseases. Incidence and mortality rates very significantly among cancer types but when all cancer are considered collectively roughly one in three individuals will get cancer and about one in five will die of cancer (in the U.S.).

- Radiation induced cancers are indistinguishable from the spontaneous or naturally occurring cancers. Breast cancer induced by ionizing radiation is indistinguishable from breast cancer that appears spontaneously.

- Cancer has a long latent period that extends from years to a few decades. Lung cancer is thought to appear about 20 years after the beginning of smoking.

- Various host factors influence cancer risk including gender and age. Children are considered at higher risk because they are young enough to live beyond the cancer latent period. Individuals exposed at age 70 have a minimal risk because they are not likely to live beyond the latency period to express disease.

19. *Supra* note 12. BEIR V Report.

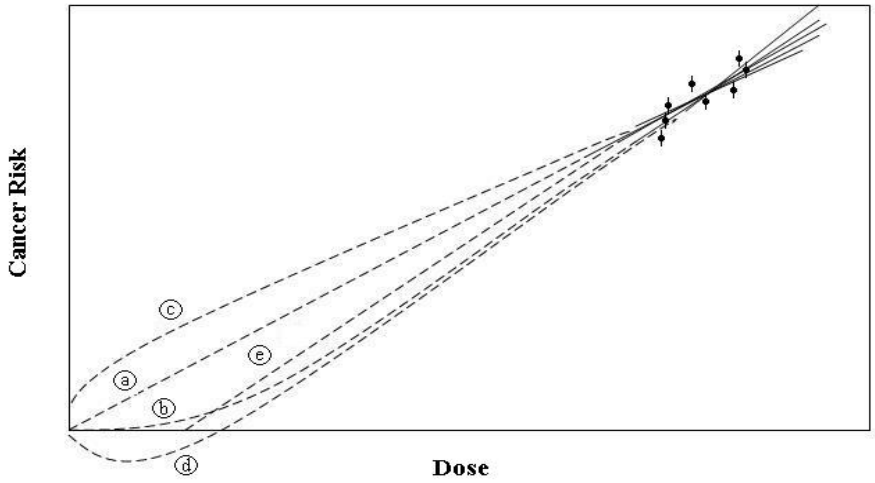
These principles make detection of small cancer risks extremely difficult to measure and to interpret. The multi-year latency period requires long term study of populations for which follow-up may be difficult. The high spontaneous rates of cancer may make it nearly impossible to detect radiation induced cancers (the signal) from the large number of spontaneous cancers that occur in the absence of radiation (the noise).

Risks at very small doses of ionizing radiation are theoretically determined and are highly uncertain. Risk estimates should be interpreted with great caution. Understanding and communicating very small risks must consider sources of uncertainty. Two major sources of uncertainty are considered below:

5.1 Estimating risks using the LNT predictive theory

Risks are uncertain in part because of lingering questions about the appropriateness of the LNT theory to predict risks at small doses.. This theory argues that any exposure to radiation is harmful, and one can calculate the probability of cancer from a linear extrapolation of observed cancer at high radiation exposures. This philosophy has led to the widespread belief that there is no safe dose of radiation and that regulations should establish exposure limits as low as possible if not zero.

Figure 1. Possible shapes of dose-response curves in risk assessment:



There are several biologically plausible theories that could be used in risk assessment Figure 1 compares (a) linear, no threshold, (b) sub-linear, (c) supra-linear, (d) hormesis or U-shape, and (e) threshold dose-response theories. As shown the different curves fit the data equally well at high doses but predict very different risks at low doses. The data points (with error bars) and the solid lines represent the region of direct observations; the dotted lines represent theoretical risk projections. Other theories predict risks that may be higher or lower than LNT derived risks. In fact the range of risk prediction at low doses is quite wide and includes the prediction of beneficial effects (hormesis prediction). Selecting a particular theory to the exclusion of alternatives is problematic because observations in the low dose range are inadequate to support a clear choice. There is now considerable evidence to suggest that the LNT theory overestimates risk in the low dose range. If the LNT theory overestimates risk then estimates of population health effects would be too high and actual detriment would be lower than predicted. In a 2001 report the National Council of Radiation Protection and Measurements admitted that there is substantial evidence against LNT but nevertheless continues to endorse LNT by concluding that no other theory was more plausible than LNT. In 2005, the National Research Council's BEIR VII Committee drew similar conclusions.[20]

5.2 Dose extrapolation and detection limits in epidemiology

20. *Supra* note 12. BEIR VII Report; National Council on Radiation Protection and Measurements. *Evaluation of the Linear Nonthreshold Dose-Response Model for Ionizing Radiation*. NCRP Report No. 136. Bethesda, MD: NCRP; 2001.

Dose extrapolation is also a serious source of uncertainty. For most carcinogens (including ionizing radiation) very large doses of the agent are needed in order to observe a statistically significant increase in cancer. This is because small doses typically encountered in environmental and occupational settings are associated with very low risks of cancer and, in the absence of any exposure, cancer occurs at a very high rate naturally (about 1 in 3 Americans will get cancer).

Predicting radiogenic health effects at environmental and occupational exposure levels requires that directly observable dose response data be extrapolated 2-3 orders of magnitude (i.e., 100-1000 times).[21] This degree of dose extrapolation strains the credibility of risk assessment at low dose and is comparable to the dose extrapolations used to "demonstrate" the human cancer-causing effects of commonly occurring chemicals including cyclamates, saccharin, Alar, and ethylene dibromide (EDB) based on laboratory animal data. Accordingly, numbers of cancer deaths due to low doses of carcinogens must be considered speculative; risk estimates at low dose have great uncertainties because they are theoretically derived. For ionizing radiation the possibility that there may be no health risks from doses comparable to natural background radiation levels cannot be ruled out; at low doses and dose rates, the lower limit of the range of statistical uncertainty includes zero.[22]

Dose estimates (Table 3) suggest that radiogenic risks are so small that they cannot be measured reliably. Figure 2 identifies the size of the population necessary to detect a significant risk at a given radiation dose (1 mSv = 100 mrem). The solid line is the boundary that defines the population size-dose space. Population sizes to the right of the boundary will be large enough to detect a significant risk for a given dose. Populations to the left of the boundary are too small to detect a radiogenic risk. To illustrate, examples of large populations exposed to small doses of radiation are plotted as points on the graph.[23] Except for the Japanese survivors that include those that received relatively high doses, no population group shown is large enough to detect significant risk.[24] An epidemiological study designed to

21. Cancer risks are statistically significant at radiation doses of 20,000 mrem and higher based on analysis of Japanese atomic bomb survivor data. The doses used to calculate risks in Table 3 of this report range from about 80 to 330 mrem when integrated over 70 years.

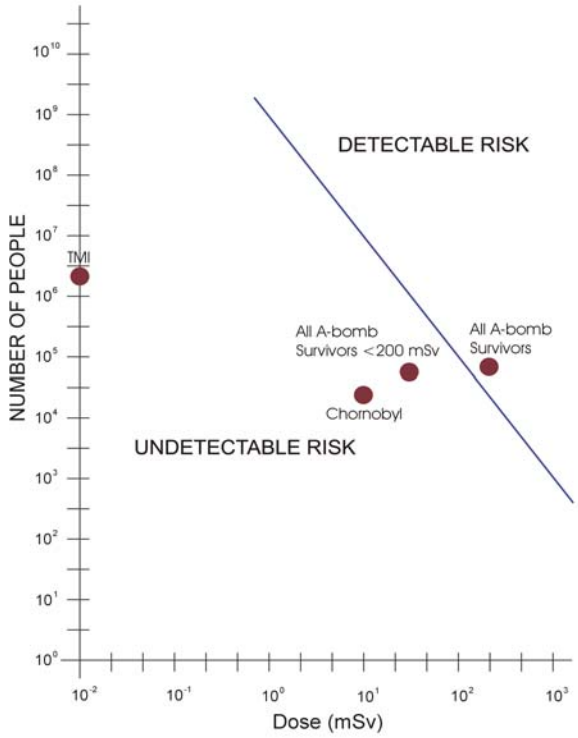
22. *Supra* note 12. BEIR V Report.

23. The point identified as "all A-bomb survivors" represents about 86,000 Japanese survivors who received an average dose of 20,000 mrem in 1945. The point identified as "all A-bomb survivors <200 mSv" refers to the 65,000 A-bomb survivors who received doses less than 20,000 mrem. The point identified as "Chornobyl" refers to the 30,000 workers who received an average dose of about 10,000 mrem as a consequence of the Chornobyl nuclear plant accident in 1986. The point identified as "TMI" refers to the 2 million members of the general public who received about 1 mrem as a consequence of the nuclear power plant accident at TMI in 1979.

24. Significant increased cancer mortality in Japanese survivors receiving more than 20,000 mrem has been reported. The majority of reports of health studies of Pennsylvania residents near TMI report no elevated risks of cancer that

detect an increased health risk in a population exposed to 4.6 mrem per year for 70 years (see Tables 3 and 4) would require a population of about 500 million persons or almost twice the size of the current U.S. population (Figure 2). Obviously it is not possible to detect such small risks.

Figure 2. Large populations are needed to detect very small radiogenic risks.



6.0 RISKS IN PERSPECTIVE

An integral part of the risk assessment and risk management exercise is framing and communicating risks. In some ways this represents the most challenging part of risk analysis. If expressed improperly, risk information can result in misunderstandings and incorrect messages that may lead to inappropriate risk management decisions.

Risk assessment is primarily carried out by scientists who may be quite detached from the real world activities that involve the risks they are studying. They often

could be attributed to radiation exposure. There have been reports of elevated thyroid cancer in children near Chornobyl. However thyroid doses were quite high due to the concentration of radioactive iodine by the thyroid glad. Otherwise there have been no consistent reporting of health detriment in the Chornobyl populations.

express risks in ways that are not understandable by the public. In addition to assessing risk, scientists have a responsibility to distill scientific and technical information into a package that can be readily comprehended by risk managers and the public. Risk managers similarly must be able to effectively communicate highly technical information in easily understandable terms for policy makers and the public. Unless workers and the public have a clear understanding of the risks and how the risks are managed they may be reluctant to buy into the technology and any particular risk reduction strategy.

6.1 Speculation Versus Reality

Using LNT theory to calculate health effects of exposure to very small doses of carcinogens is now so ingrained that real risks are no longer distinguishable from calculated, theoretical risks. Body bags are viewed the same whether they are real or calculated. Unwillingness to distinguish reality from speculation poses enormous problems in risk assessment and management. The idea that no dose is safe, and concerns for "trivial risks" has contributed to a system of increasingly restrictive regulations.

The idea that any dose is potentially harmful has led to unwarranted fears about radiation. In one survey of primary care physicians in Pennsylvania, 59% of the doctors identified fear of radiation as the primary reason for their patients' refusal of mammography examinations. Women who refuse mammography may be denying themselves an important medical benefit by compromising early detection and the subsequent management of disease. Following the Chornobyl accident in 1986, the International Atomic Energy Agency estimated 100,000-200,000 Chornobyl-related induced abortions in Western Europe. In Greece, as in other parts of Europe, many obstetricians initially thought it prudent to interrupt otherwise wanted pregnancies or were unable to resist requests from worried pregnant women in spite of the fact that doses were much lower than necessary to produce *in utero* effects.[25]

6.2 Communicating Risks

Risk communication is important because public perceptions of risk do not always match the actual risks. People fear the wrong things. We fret about activities that involve small risks and do not pay enough attention to risks that are significant and

25. Fear of radiation-induced cancer or other health effects is one of many factors that might be considered by individuals who decline medical x-ray procedures and by pregnant women who elect to have abortions. For instance, women also decline to have mammography procedures because of the cost of the procedure or pain and discomfort. See Albanes, D. et al. A survey of physicians' breast cancer early detection practices. *Preventive Medicine* **17:** 643-652; 1988. Trichopoulos, D. et al. The victims of Chernobyl in Greece: Induced abortions after the accident. *British Medical Journal* **295:** 1100; 1987.

about which we can do something about. Consider automobile travel and airplane travel. Many people will not fly but have no hesitancy about getting into a car. In the 1990s Americans were, on a mile for mile basis, 37 times more likely to die in a car crash than on a commercial airliner. Commercial airline travel is so safe that the chances of dying in any flight are less than tossing heads twenty-two times in succession.[26] Although the risks are substantially higher for automobile travel, people do not seem to think the risks are anything to worry about. According to the National Highway Traffic Safety Administration, automobile traffic safety belts save about 9,500 lives per year. When used properly seat belts reduce fatal injury risk to front seat car passengers by 45%. More than 25% of Americans do not use seat belts.

Cigarette smokers who worry about radiation from mammograms or chest X- rays have perceptions of risk that are not congruent with what we actually know about these risks. There is no evidence that chest X-rays and mammograms kill anyone. However, cigarettes kill more than 400,000 people every year from cancer and heart disease. Certainly whether the risk is considered voluntary or controllable impacts how it is perceived. There is substantial literature on the subject of risk perception.[27]

The Health Physics Society[28] has issued two relevant position statements. The first statement titled "Radiation Risk in Perspective" concludes that although there is substantial and convincing scientific evidence for health risks following high-dose exposures, below 5,000-10,000 mrem risks are either too small to be observed or are nonexistent. The Society recommends that below 5000 mrem in one year or a lifetime dose of 10,000 mrem above natural background risk estimates should not be used. Expressions of risk should only be qualitative, that is, a range based on the uncertainties in estimating risk emphasizing the inability to detect any increased health detriment (that is, zero health effects is a probable outcome).[29] In the second statement titled "Ionizing Radiation –Safety Standards for the General Public" the Health Physics Society supports the establishment of an acceptable dose of radiation of 1 mSv/y (100 mrem/y) above the annual natural radiation background.

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26. Myers, D.G. Do we fear the right things? *Skeptic* **10 (1):** 56-57; 2003.
27. Slovic, P. *The Perception of Risk*. London: Earthscan Publications, Ltd. 2000.
28. The Health Physics Society is a nonprofit scientific professional organization whose mission is excellence in the science and practice of radiation safety . The Society has approximately 6000 scientists, physicians, engineers, lawyers, and other professionals. Society activities include encouraging research in radiation science, developing standards, and disseminating radiation safety information. Society members are involved in understanding, evaluating and controlling the potential risks from radiation relative to the benefits.
29. Health Physics Society, Radiation Risk in Perspective, Position Statement of the Health Physics Society. *Health Physics News* **XXXII (10):** 15-16; October 2004.

At this dose, risks of radiation-induced health effects are either nonexistent or too small to be observed.[30]

30. Health Physics Society, *Ionizing Radiation –Safety Standards for the General Public.* Accessed at http://hps.org/documents/publicdose03.pdf

Appendix G: Nuclear Waste Historical and Forecast Data

The following information responds to Minn. R. 7855.0620, which requires five-years of historical data and forecast of demand on a nuclear waste storage or disposal facility. The rule was written to encompass nuclear waste storage facilities that would accept nuclear waste from nuclear facilities all over the United States. However, Minnesota law restricts on-site storage at Minnesota's nuclear generating plants to nuclear waste generated at that facility.

Under Minn. Stat. § 116C.83, AUTHORIZATION FOR ADDITIONAL DRY CASK STORAGE, Subdivision 4, Paragraph (b) *The authorization for storage capacity pursuant to this section is limited to the storage of spent nuclear fuel generated by a Minnesota nuclear generation facility and stored on the site of that facility.*" Paragraph A of 7855.0620 only requires historical and forecast data:

> *Minn. R. 7855.0620 (A).*
> *For each material that would be stored in the proposed facility, the amount (in cubic meters) produced nationally and within Minnesota during each of the last five calendar years preceding the year of application.*

Consequently, the information provided in response to this requirement is limited to the spent fuel generated at Prairie Island, which is the subject of this Certificate of Need.

No material other than that generated at Prairie Island can be stored in the proposed facility. Table G-1 contains the number of spent fuel assemblies that were discharged at Prairie Island from 2003 to 2007 and the equivalent metric tons of uranium and volume of those assemblies.

TABLE G-1 RESPONSE TO 7855.0620 – ITEM A	
HISTORICAL ANNUAL SPENT FUEL DISCHARGES AT PRAIRIE ISLAND	
Year	**NUMBER OF ASSEMBLIES**
2003	48
2004	48
2005	46
2006	104
2007	0
Year	**EQUIVALENT METRIC TONS OF URANIUM**
2003	17
2004	17
2005	17
2006	37
2007	0
Notes: Assumes approximately 0.360 MTU per assembly at Prairie Island	
Year	**EQUIVALENT CUBIC METERS OF SPENT FUEL**
2003	8
2004	8
2005	7
2006	16
2007	0
Notes: Assumes a Prairie Island PWR fuel assembly 160 inches long, with a 7.76-inch square cross section.	

Minn. R. 7855.0620 (B).
For each of the last five calendar years preceding the year of application, the year-end capacity (in cubic meters) within Minnesota and within the United States to store the materials listed in response to item A.

No material other than that generated at Prairie Island can be stored in the proposed facility. Similarly, only material generated at our Monticello nuclear plant can be stored in the Monticello storage facility. Storage facilities at nuclear generating plants located outside Minnesota are not licensed by the NRC and not available for Prairie Island's use.

Table G-2 lists the historical year-end dry cask storage units remaining at Prairie Island by the number of spent fuel assemblies and the equivalent metric tons of uranium and volume of those assemblies. Table G-3 lists the inventories of away from the reactor dry cask storage facilities. The storage facilities listed in Table G-3 are no longer accepting spent fuel from utilities and will, therefore, not be available as storage facilities in the future.

TABLE G-2 RESPONSE TO 7855.0620 – ITEM B	
HISTORICAL YEAR-END REMAINING DRY CASK STORAGE CAPACITIES AT PRAIRIE ISLAND	
YEAR	**NUMBER OF ASSEMBLIES**
2003	651
2004	602
2005	556
2006	452
2007	451
YEAR	**EQUIVALENT METRIC TONS OF URANIUM**
2003	234
2004	217
2005	200
2006	163
2007	162
Notes: Assumes approximately 0.360 MTU per PWR assembly	
YEAR	**CUBIC METERS**
2003	103
2004	95
2005	88
2006	71
2007	71
Notes: Assumes a Prairie Island PWR fuel assembly 160 inches long, with a 7.76-inch square cross section.	

TABLE G-3 RESPONSE TO 7855.0620 – ITEM B CURRENT INVENTORIES AT SPENT FUEL STORAGE FACILITIES (SPENT FUEL ASSEMBLIES)			
Storage Facility	**Current Inventory**		
	PWR	**BWR**	**HTGR**
GE Morris Facility	352	2865	0
Idaho National Engineering Laboratory	133	89	720
Ohio Battelle	1	0	0
Vallecitos Nuclear	0	1	0
Washington Hanford	5	2	0

Minn. R. 7855.0620 (C).
An estimate of the amount (in cubic meters) of each material listed in response to item A expected to be produced nationally and within Minnesota during the first six forecast years, the 11th forecast year (the tenth year after the year of application), and the 16th forecast year.

No material other than that generated at Prairie Island can be stored in the proposed facility. Table G-4 contains the estimated number of spent fuel assemblies to be discharged at Prairie Island from 2008 to 2013, 2018 and 2023 and the equivalent metric tons of uranium and volume of those assemblies.

TABLE G-4 RESPONSE TO 7855.0620 – ITEM C PROJECTED ANNUAL SPENT FUEL DISCHARGES AT PRAIRIE ISLAND	
YEAR	**NUMBER OF ASSEMBLIES**
2008	97
2009	49
2010	56
2011	44
2012	89
2013	44
2018	97
2023	49

TABLE G-4 RESPONSE TO 7855.0620 – ITEM C	
PROJECTED ANNUAL SPENT FUEL DISCHARGES AT PRAIRIE ISLAND	
Year	**METRIC TONS OF URANIUM**
2008	36
2009	18
2010	20
2011	16
2012	32
2013	16
2018	35
2023	18
Notes: Assumes approximately 0.360 MTU per PWR assembly	
Year	**CUBIC METERS**
2008	15
2009	8
2010	9
2011	7
2012	14
2013	7
2018	15
2023	8
Notes: Assumes a PWR fuel assembly 160 inches long, with a 7.76-inch square cross section.	

Minn. R. 7855.0620 (D).
A list of known facilities to be added in the United States during the forecast years, including locations, design capacities (in cubic meters), and in-service dates, for storing the same types of materials that would be stored in the proposed facility.

Storage facilities at nuclear generating plants outside of Minnesota are not licensed by the NRC to store Prairie Island's used fuel. Similarly, only material generated at our Monticello nuclear plant can be stored in the Monticello spent fuel storage facilities. Table G-5 provides the required information for the known facilities that could in the future accept the used fuel proposed to be stored at Prairie Island.

TABLE G-5 RESPONSE TO 7855.0620 – ITEM D
PLANNED CENTRALIZED PRIVATE OR DEPARTMENT OF ENERGY FACILITIES FOR DRY CASK STORAGE
Geologic Repository for Spent Nuclear Fuel and High Level Waste Operator: Department of Energy Location: Yucca Mountain, Nevada Capacity: 70,000 MTU prior to operation of a second repository with present legislation. In-service date: Unknown at this time. Prior to 2025
Private Fuel Storage, LLC Operator: Private Fuel Storage, LLC Location: Skull Valley, Utah Capacity: 40,000 MTU In-service date: Unknown at this time.

Minn. R. 7855.0620 (E).
The expected years during which the material stored in the proposed facility would reach ten percent, 25 percent, 50 percent, and 100 percent of the capacity of the facility.

This data is provided in Table G-6. The dry cask storage capacities are based on Prairie Island spent fuel discharges that are consistent with those projected in response to subpart C of the Rule. The table shows the percent capacity of the proposed increase in storage capacity as well as the total number of assemblies, i.e. the total number includes the current authorized storage. Sufficient discharge capacity is assumed to be reserved in the Prairie Island spent fuel pool to accommodate a discharge capacity reserve equivalent to two full core off-loads (242 assemblies).

TABLE G-6 RESPONSE TO 7855.0620 – ITEM E		
RATE AT WHICH THE PROPOSED NEW CAPACITY OF THE PRAIRIE ISLAND INDEPENDENT DRY CASK STORAGE INSTALLATION WOULD BE FILLED WITH SPENT FUEL		
Year Spent Fuel in Independent Dry Cask Storage Installation Reaches Specified Percent of Capacity	Percent of Independent Dry Cask Storage Installation Capacity Utilized	Assemblies In Dry Cask Storage (includes number of assemblies in new and existing casks)
2011	10% (3 of 35 proposed casks)	1,280
2015	25% (8 of 35 proposed casks)	1,520
2020	50% (16 of 35 proposed casks)	1,880
2033	100% (35 proposed casks)	2,560

Minn. R. 7855.0620 (F).
A discussion of the methodology, statistical techniques, and data bases used in providing the forecast data required by items C and E.

The forecasts are based on the planned fuel loadings for Prairie Island.

Minn. R. 7855.0620 (G).
Any major assumptions made in supplying the information required by items A to E, and a discussion of the sensitivity of the information to changes in the assumptions.

Items A, B and C:

- Assumes approximately 0.360 MTU per assembly at Prairie Island
- Assumes a Prairie Island PWR fuel assembly 160 inches long, with a 7.76-inch square cross section.

Appendix H: Plant Operation Considerations (Life Cycle Management)

H.1 Ongoing Process for Identifying Emerging Aging Issues

The key issue in the federal regulatory scheme associated with license renewals is a review of aging management practices for long-lived passive components in safety systems. Because nuclear plants are the most highly regulated facilities in the nation, with NRC inspectors on-site around the clock, safety performance, equipment reliability and human errors are immediately reportable and are subsequently reviewed to extract lessons learned and to avoid repeat events. The plant must be maintained in a condition that continues to evaluate any potential erosion of design and safety margins, regardless of how long the facility operates. Plants that fall below the performance standards established and monitored by the NRC experience increased inspections, possible fines and/or are shutdown until performance improves. Generic industry performance data for all nuclear plants is monitored and accumulated by INPO and the NRC and are reported on an annual basis. The trends over the last ten years show a continuous performance improvement for all plants, regardless of age or size. The forced outage rate percentage per year has been steadily reduced from about 10.21 to 1.47, challenges to safety systems have been reduced from about 0.35 to 0.22 safety system actuations per plant per year. Most dramatically, the number of safety system failures has been reduced from about 2.72 to 0.58 failures per plant per year. Plants have learned to manage aging and to reduce uncertainty in operations and cost. The following is a summary of the aging management tools used in assuring that the Plant continues to meet NRC standards.

A. Experience gained from the operation of other plants is entered into central data banks, such as the Licensee Event Reports (LER) by the NRC and the EPIX database operated by INPO. The relevant events occurring at other plants are continuously monitored by the Plant to search for potentially applicable occurrences, which may be precursors to future events at the Plant. This provides an opportunity to look for signs of similar behavior and to implement preventive actions prior to failure. For instance, if piping corrosion or erosion is detected in one plant, other plants are alerted to proceed with additional inspection and testing to verify the absence of similar degradation and if found, implement early remedies to avoid failure, a possible plant shutdown and lost electric production.

B. The industry and NRC have conducted comprehensive aging studies for all major plant components to predict the degradation type, location and rate. With this knowledge, the Plant adjusts its maintenance practices to look for the initiation of degradation to discover any indication of aging and to repair or mitigate the effects. Areas of uncertain degradation are monitored periodically to detect the start of degradation, such as frequent wall thickness measurement of piping subject to corrosion thinning.

C. Plant systems are also monitored for performance with respect to reliability (standby safety systems), availability (continuous operating systems) and functional failures, as required by relevant NRC rules such as the Maintenance Rule (10 C.F.R. Part 50.65). Acceptance standards are established for each system and when exceeded, immediate corrective action must be taken to bring the system performance back into compliance. Through this process, equipment problems are caught early to allow timely corrective or preventive actions.

D. Some of the equipment aging mechanisms are affecting many other plants with identical or similar equipment. In these instances, the affected plants are joining in efforts to find solutions to reduce or eliminate the degradation. These projects may be undertaken by Owners Groups or EPRI (such as the Materials Research Program, MRP). Monticello frequently utilizes industry programs to reduce individual plant costs and assure consistent implementation of fixes.

E. The Probabilistic Risk Assessment (PRA) for the Plant consists of a detailed model to reflect the current plant configuration. Using the model to analyze the risk associated with a variety of accident scenarios provides an insight as to the most important systems and components necessary to operate the plant in the safest way. Maintenance and reliability of these critical systems components is prioritized to assure that they remain functional under the different postulated accidents.

F. Ongoing regulatory review identifies operating events at another plant can trigger new NRC mandates to replace equipment, implement new safety measures or enhance inspections. These mandates are not unique to license renewal and will apply to all plants affected by the new requirements and will maintain or improve the margins for all plants.

H.2 License Renewal Process

The NRC license renewal process requires a significant review of the plant and its processes to assure safety margins consistent with the current licensing basis are maintained during the period of the renewed license. The license renewal process is described here to provide context for the review done by the NRC. The plant operates under a license issued by the NRC. The NRC is limited to issuing initial operating licenses to commercial nuclear power reactors for a period of 40 years. The 40-year initial license period was based on the typical depreciation period for a large industrial facility. It was not based on any physical limitations inherent in commercial nuclear power reactors. Industry studies were initiated in the 1980s to evaluate the feasibility of operating commercial nuclear power reactors beyond the initial 40-year period. Two plants were reviewed as part of initial DOE/EPRI studies (one of which was the Xcel's Monticello plant). These studies concluded that commercial nuclear power reactors could safely operate well beyond the initial license period. As a result, the NRC entered into rulemaking to establish a regulatory process for renewing operating licenses. The resulting license renewal regulations allow for an operating license to be renewed in 20-year increments. The license renewal process requires that both a technical review of safety issues and an environmental review be performed for each application. NRC regulations, 10 CFR Part 54 and 10 CFR Part 51, contain the requirements for these reviews.

H.2.1 Technical Review Process (10 CFR Part 54)

The license renewal technical review process is based on two key principles:
The NRC's regulatory process, continued into the extended period of operation, is adequate to ensure that the current licensing basis of all currently operating plants provides an acceptable level of safety, with the possible exception of the detrimental effects of aging on certain systems, structures, and components, and possibly a few other issues related to safety only during the period of extended operation, and Each plant's current licensing basis is required to be maintained during the renewal term.

10 CFR Part 54, focuses on managing adverse effects of aging; rather than identification of all aging mechanisms. The rule is intended to ensure that important systems, structures, and components will continue to perform their intended function in the period of extended operation. In addition, an integrated plant assessment (IPA) process was clarified and simplified to be consistent with a revised focus on passive, long-lived structures and components.

Prior to submission of a renewal application, an applicant must analyze the management of aging effects in sufficient detail to conclude that the plant can be operated safely during the period of extended operation. The renewal application is the principal document in which the applicant provides the information needed to understand the basis upon which this conclusion has been reached. The license renewal application must contain technical information and evaluations about the different types of plant aging that might be encountered in the specific plant and how the licensee will manage or mitigate those aging effects. This information must be sufficiently detailed to permit the NRC staff to determine whether the effects of aging will be managed such that the plant can be operated during the period of extended operation without undue risk to health and safety of the public. The NRC staff performs a safety review of the information provided in the application, requesting additional information from the applicant as necessary, and draws conclusions about whether the plant can be operated during the period of extended operation without undue risk to health and safety of the public. The general information contained in the license renewal application is similar to that provided in the initial operating license application.

The applicant must provide NRC with an evaluation that addresses the technical aspects of plant aging and describes the ways those effects will be managed over the life of the nuclear plant. This includes the following information:

H.2.1.1 Integrated Plant Assessment

An Integrated Pant Assessment identifies and lists structures and components subject to an aging management review (AMR). These include "passive" structures and components that perform their intended function without moving parts or without a change in configuration or properties. These include such components as the reactor vessel, the steam generators, piping, component supports, seismic Category I structures, etc. To be in scope, the item must also be "long-lived" to be considered during the license renewal process. Long-lived means the item is not subject to replacement based on a qualified life or specified time period.

H.2.1.2 Current Licensing Basis

A plant's Current Licensing Basis (CLB) can change during the NRC's review of the license renewal application. Each year following submittal of the license renewal application and at least 3 months before scheduled completion of the NRC review, an amendment to the renewal application must be submitted that identifies

any change to the CLB of the facility that materially affects the contents of the license renewal application, including the Final Safety Analysis Report supplement.

H.2.1.3 Time-limited Aging Analyses

An evaluation of Time-limited Aging Analyses (TLAAs), which are calculations or analyses that involve systems, structures, and components within scope of the rule, consider the effects of aging, and involve assumptions based on the original 40-year operating term. For license renewal, TLAAs must be: (a) verified to bound the renewal period; (b) reanalyzed (recalculated) to determine if it will bound the renewal period; or (c) the applicant must show that the aging effects encompassed by the calculation will be managed.

H.2.1.4 Final Safety Analysis Report

A supplement to the Final Safety Analysis Report, which provides a summary description of the programs and activities for managing the effects of aging and evaluation of TLAAs for the period of extended operation.

H.2.1.5 Technical Specifications

Technical specification changes or additions, with justification, necessary to manage the effects of aging during the period of extended operation must be included in the license renewal application.

H.2.2 Environmental Review (10 CFR Part 51)

The NRC is also charged with protection of the environment in the use of nuclear materials. Each license renewal applicant must include a supplement to the environmental report that contains an analysis of the plant's impact on the environment if allowed to continue operation beyond the initial license. The NRC performs plant-specific reviews of environmental impacts of operating life extension in accordance with National Environmental Policy Act (NEPA) and the requirements of 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." This review continues on a separate "track" from the safety reviews of the technical information. Environmental requirements for the renewal of power reactor operating licenses are contained in NRC's regulations, 10 CFR Part 51.

H.2.2.1 Generic Environmental Impact Statement

The Generic Environmental Impact Statement (GEIS) examines the possible environmental impacts that could occur as a result of renewing any commercial nuclear power plant license, and, to the extent possible, establishes the bounds and significance of these potential impacts. For each type of environmental impact, the GEIS attempts to establish generic findings covering as many plants as possible. While plant and site-specific information is used in developing an envelope of generic findings, the NRC does not intend for the GEIS to be a compilation of individual plant environmental impact statements. Instead, an applicant into a license renewal application environmental report may incorporate this report. The GEIS makes maximum use of environmental and safety documentation from original licensing proceedings and information from state and federal regulatory agencies, the nuclear utility industry, the open literature, operating experience, and professional contacts. It allows the applicant to concentrate on those impacts that must be evaluated on a plant-specific basis. Information provided on the plant specific issues will either disposition the issue as not applicable or present an analysis of the issue using site-specific information. Mitigation and alternatives to reduce adverse impacts must also be discussed.

H.2.2.2 Environmental Scoping Process

A scoping process is conducted to define the proposed action, to determine the scope of the EIS and identify the significant issues to be analyzed in depth. A public scoping meeting is held near the nuclear plant seeking license renewal. Based on this process and the staff's independent review, the NRC will issue a preliminary recommendation on the acceptability of a license renewal action with regard to environmental impact. A draft plant-specific supplement to the GEIS is released for public comment and a public meeting is then held to discuss the findings. After comments are addressed, the NRC publishes a final plant-specific supplement to the GEIS and provides a final recommendation regarding the license renewal application to the Commission. Transcripts of environmental scoping meetings and public meeting on the draft supplements related to license renewal are available through the NRC Public Document Room.

H.2.3 Review Time

It is currently expected that the NRC staff will complete its review of the application within 30 months from receipt if a hearing is required or within 22 months from receipt if no hearing is required. A nuclear power plant licensee may

apply for license renewal as early as 20 years before the expiration of its current license and no later than 5 years before the expiration of its current license.

H.2.4 Inspection Program

The license renewal inspection program is implemented prior to the approval of an application for a renewed license, to verify that an applicant, requesting a renewed license under 10 CFR Part 54 meets the requirements of the rule and has implemented license renewal programs and activities consistent with their license renewal application and the NRC's safety evaluation report. The primary objectives of license renewal inspection activities are to review the documentation, implementation, and effectiveness of the programs and activities associated with an applicant's license renewal program to verify that there is reasonable assurance that the effects of aging will be adequately managed such that the intended function of components and structures within the scope of license renewal will be maintained consistent with the current licensing basis during the period of extended operation.

H.2.5 Public Involvement in Reactor License Renewal

As with any licensing activity, the public has an opportunity to participate in NRC's decision-making process with regard to license renewal. Guidance for the review process is based not only on NRC views, but on industry experience as well. Furthermore, the expertise of technical organizations and professional societies was used, as appropriate, during the development of the license renewal process. The public, in general, is also encouraged to participate in the process through public meetings, and public comment periods on rules, renewal guidance, and other documents. In addition, the public has an opportunity to request a formal adjudicatory hearing if that party would be adversely affected by the renewal.

H.2.6 Public Meetings

The public can keep abreast of NRC's reactor license renewal regulatory activities through a variety of open meetings, including commission meetings, advisory committee meetings, and staff meetings open to the public.

H.2.7 Adjudicatory Process

The NRC conducts hearings on disputed matters involved in the re-licensing of nuclear reactors. The NRC regulations that govern the hearing process are in Rules

of Practice for Domestic Licensing Proceedings and Issuance of Orders (Part 2 of Title 10 of the Code of Federal Regulations (10 CFR Part 2).

Appendix I: Power Uprates Approved by the NRC

I.1 Power Uprates Experience

E.1.1 Power Uprate Approved Applications:

- Calvert Cliffs, Units 1 and 2
- Millstone, Unit 2
- H.B. Robinson Nuclear Plant[1]
- Fort Calhoun Station
- St. Lucie, Units 1 and 2
- Duane Arnold[2]
- Salem, Units 1[3] and 2
- North Anna, Units 1 and 2
- Callaway
- Three Mile Island, Unit 1
- Fermi, Unit 2
- Vogtle, Units 1 and 2
- Wolf Creek
- Susquehanna, Units 1 and 2[4]
- Peach Bottom, Units 2 and 3[5]
- Limerick, Units 1 and 2
- Nine Mile Point, Unit 2
- Washington Nuclear Plant, Unit 2
- Surry, Units 1 and 2
- Hatch, Units 1 and 2 [6]
- V.C. Summer Nuclear Station
- Palo Verde Units 1 thru 3[7]

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[1] Approval for 4.5% in 1979 and 1.7% in 2002.

[2] Approval received for 4.1% uprate in 1985 and 15.3% in 2001.

[3] Unit 1 was approved for a 2% uprate in 1986 and 1.4% in 2001.

[4] Two different applications in 1994, 1995 for Units 2 and 1 respectively and then in 2001. The first request was for a
4.5 % uprate and the second for a 1.4% uprate.

[5] Approval was granted in 1994 for 5% at Unit 2 and in 1995 for Unit 3. Both Units were also approved for 1.62% in\
2002.

[6] Three applications: 1995 (5%), 1998 (8%), 2003 (1.5%).

[7] All Units approved at 2% in 1996 and Unit 2 at 2.9% in 2003 and Units 1 and 3 for 2.9% in 2005.

- Turkey Point Nuclear Plant, Units 3 and 4
- Brunswick, Units 1 and 2[8]
- James A FitzPatrick
- Farley, Units 1 and 2
- Browns Ferry, Units 1, 2 and 3
- Prairie Island
- Comanche Peak, Units 1 and 2[9]
- LaSalle, Units 1 and 2
- Perry
- River Bend[10]
- Diablo Canyon, Unit 1
- Watts Bar
- Byron, Units 1 and 2
- Braidwood, Units 1 and 2
- San Onofre, Units 2 and 3
- Hope Creek
- Beaver Valley, Units 1 and 2[11]
- Shearon Harris
- Dresden, Units 2 and 3
- Quad Cities, Units 1 and 2
- Waterford[12]
- Clinton
- South Texas, Units 1 and 2
- ANO-2
- Grand Gulf Nuclear Station
- Sequoyah, Units 1 and 2
- Indian Point, Units 2 and 3[13]
- Crystal River Nuclear Generating Plant, Unit 3
- Point Beach, Units 1 and 2
- D.C. Cook, Units 1 and 2
- Kewaunee Power Generating Station[14]
- Pilgrim

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[8] Approval for 5% in 1996 and 15% in 2002.

[9] Unit 2 received approval for a 1% uprate in 1999 and approval for 0.4% in 2001.

[10] Approved for 5% in 2000 and 1.7%in 2003.

[11] Approved for 1.4% in 2001 and 8% in 2006.

[12] Unit 3 1.5% in 2002 and all units for 8% in 2005.

[13] Approvals for 1.4% for Units 3 and 2 in 2002 and 2003, respectively and 3.26% in 2004 and 2005, respectively

[14] Approved for 1.4% in 2003 and 6% in 2004.

- Palisades
- Seabrook[15]
- Vermont Yankee
- Ginna

[15] Approved for 5.2% in 2005 and 1.7% in 2006.