CHAPTER 9. ALTERNATIVES (MINN. R. 7855.0610)

Commission Rules regarding CN applications for a nuclear waste storage facility require applications to include "a description of alternatives available to the applicant that differ significantly from the proposed facility with respect to location, size, timing or design." This Chapter discusses storage alternatives, including alternative technologies and alternative locations. In addition, because the Monticello Plant will exhaust its spent fuel storage capacity by 2030, denial of the CN would lead to closure of the Monticello Plant at that time, requiring replacement of the capacity and energy provided by the Plant. Therefore, this Chapter also examines "generation alternatives."[1]

9.1 STORAGE ALTERNATIVES

9.1.1 Alternatives to On-Site Storage

This section of our application examines four away-from-reactor storage possibilities for spent nuclear fuel: 1) reprocessing spent nuclear fuel, 2) contracting for additional spent fuel storage capacity at an existing offsite spent fuel storage facility, 3) contracting for additional spent fuel storage capacity at an offsite interim spent fuel storage facility in the future, and 4) the availability of a federally-sponsored permanent repository for spent fuel at Yucca Mountain. We conclude that none of the four represent a viable alternative to support continued operation of the Plant beyond 2030, when the current storage capacity at the Plant will be exhausted.

9.1.1.1 Reprocessing Spent Nuclear Fuel

Reprocessing is a method of recovering unused uranium and plutonium from used nuclear fuel and recycling it for use in new reactor fuel. Reprocessing does not result in elimination of all nuclear wastes and radioactivity, but does reduce the volume of high-level waste to be stored.

When electric power companies first considered using nuclear energy to generate electricity, it was assumed that when the nuclear fuel was used up or "spent", it would be recycled so that useful fuel could be extracted and used again. Approximately 96%

[1] It should be noted, however, that even if the instant CN were denied (i.e. the "No Action" alternative), Xcel Energy would still require additional spent fuel storage capacity in order to decommission the Plant, meaning a future CN would be required.

of spent fuel from nuclear plants in the United States is uranium that could potentially be reprocessed into usable fuel for electricity generation.

In 1977, President Carter, concerned about the possibility of nuclear proliferation, banned commercial reprocessing by private companies. As a result, the two private reprocessing facilities, then under final construction, were never made operational. Although the ban was eventually lifted, because of the economics of reprocessing compared to fabrication of new fuel and the political uncertainty surrounding reprocessing, no private companies have invested in constructing and operating reprocessing facilities in the United States.

As a result, reprocessing is not a viable alternative to establishing further on site dry storage at the Plant.

9.1.1.2 Existing off-site storage facilities

The only facility storing spent fuel on a contract basis from commercial nuclear power reactors is the General Electric Morris facility in Morris, Illinois. The Company shipped 1,058 spent fuel assemblies from Monticello to the Morris facility in the 1980s, where they are currently stored under contract. However, the General Electric Morris facility is no longer accepting spent fuel from commercial nuclear power plants and is therefore not a viable existing off-site alternative to the ISFSI for storing additional casks.

9.1.1.3 Private Centralized Interim Storage

9.1.1.3.1 Private Fuel Storage, LLC

Xcel Energy pursued an interim spent fuel storage project in Utah as part of the eight-utility consortium Private Fuel Storage (PFS). PFS proposed to build an interim spent fuel storage facility on the West Central Utah reservation of the Skull Valley Band of Goshute Indians.

In February 2006, the NRC issued PFS a license for the interim storage facility. Because of PFS's lengthy NRC approval process, companies who were initially interested instead constructed onsite dry fuel storage facilities. Reviving the PFS project would require the DOI's approval of the lease and the grant of the right-of-way, the resolution of the judicial challenge at the D.C. Circuit, compliance with NRC license conditions, and sufficient interest and commitment to use the facility by companies with spent fuel. None of these conditions are currently in place, and therefore this is not a viable not a viable alternative to establishing further on site dry storage at the Plant.

9.1.1.3.2 Interim Storage Partners (ISP) Storage Facility

A centralized interim storage project was initiated by Waste Control Specialists (WCS) for a site in Andrews County, Texas, adjacent to WCS's existing low-level radioactive waste and hazardous waste storage and disposal facilities. The NRC license application for this project was filed in April 2016. In April 2017, WCS asked the NRC to suspend the review of this application. Subsequently, WCS and Orano USA (formerly Areva Nuclear Materials) formed a joint venture to license the facility. In response to letters to the NRC in June and July 2018 from the joint venture, Interim Storage Partners (ISP), the NRC restarted its review of the application. A number of environmental and other organizations sought to intervene in the NRC proceeding and two organizations moved the Commission to reject the application (and the Holtec application described below), alleging that the NRC lacked the jurisdiction to consider the application. The Commission denied those latter requests and one of the organizations appealed the NRC's denial to the D.C. Circuit in December 2018.

> On the NRC's motion, the Court dismissed the case in June 2019, as not ripe for judicial review. In August 2019, the Atomic Safety and Licensing Board considered the hearing requests, admitted one contention submitted by one of the petitioners, and dismissed the remaining contentions and petitioners. A subsequent Licensing Board decision dismissed the remaining contention as moot and rejected an attempt to amend. The Board also dismissed another petitioner's late-filed contention. Appeals from the Board decisions, as well as a motion to reopen the proceeding, were denied by the Commission. The Commission also rejected a late-filed contention not previously ruled on by

the Board. Appeals of the Commission decisions to the DC Circuit are being held in abeyance by the Court pending completion of the NRC proceeding. The NRC Staff's most recently announced date for making its licensing decision on the application is September 2021.

9.1.1.3.3 Holtec HI-STORE Consolidated Interim Storage Facility

Holtec International has proposed the HI-STORE Centralized Interim Storage Facility for a site in Eddy and Lea Counties in southeastern New Mexico. Holtec filed an application with the NRC for this facility in March 2017. In response to NRC's July 2018 notice of opportunity for hearing, a number of environmental and other organizations filed petitions to intervene in the NRC proceeding. At about the same time, two organizations moved the Commission to reject the application (and the ISP application described above) alleging that the NRC lacked the jurisdiction to consider the application. After the Commission denied those requests, one of the organizations filed an appeal with the U.S. Court of Appeals for the D.C. Circuit in December 2018. On the NRC's motion, the Court dismissed the case in June 2019 as not ripe for judicial review. In May 2019, the Atomic Safety and Licensing Board issued a Memorandum and Order rejecting all the petitions to intervene filed in response to the July 2018 opportunity for hearing. Five of the six petitioners filed appeals with the Nuclear Regulatory Commission challenging the Licensing Board's rejection of their petitions. In April 2020, the Commission rejected all the appeals except for remanding to the Licensing Board four contentions put forward by one of the petitioners. In June and September 2020 orders, the Board denied the admission of the remanded contentions and other late-filed contentions—as well as motions to reopen the proceeding. Additionally, in June 2020, April 2021, and June 2021 four of the petitioners who were denied admission in the NRC proceeding filed appeals before the U.S. Court of Appeals for the D.C. Circuit. The Court has consolidated these appeals and is holding them in abeyance pending the completion of the NRC proceedings. The NRC Staff's most recently announced dates for completing its review of the application is November 2021 for the environmental review and January 2022 for the safety review.

While we believe the centralized storage facilities proposed by ISP and Holtec meet all NRC regulatory requirement and would be a positive development in the management of spent nuclear fuel, we do not consider it a viable alternative to granting additional storage capacity at the Monticello ISFSI at this time. Environmental and safety reviews are ongoing at the Nuclear Regulatory Commission, and the Commission expects to issue the licenses for the two facilities by early 2022. After receiving the NRC license, each facility will need to work with their respective states on permitting issues and will develop a business model for operations prior to construction. In addition, the Department of Energy will begin their own process to find a consent-based interim storage location over the next few months and it is unclear how this will impact the two private facilities currently in licensing.

At Monticello, we will need to load the next dry cask storage containers in the 2028 timeframe. Without a set schedule or guarantee that any of the interim facilities will open in the near term, we do not believe it would be prudent to consider either of these a viable alternative to additional on-site storage at Monticello at this time.

9.1.1.4 Yucca Mountain

The application to license the Yucca Mountain permanent repository remains pending before the NRC, following the unsuccessful attempt by the Obama Administration to terminate the proceeding and withdraw the application. The NRC Staff's technical and environmental reviews have been essentially completed, but the adjudicatory hearings on the application before NRC Atomic Safety and Licensing Board remain suspended—with numerous contentions submitted by Nevada and other opponents remaining to be resolved before the NRC can license the project. The Administration did not seek any funding for Yucca Mountain in the FY2021 budget and is not seeking any in FY2022. During Senate committee hearings in June 2021, Secretary of Energy Granholm testified that the Administration does not support Yucca Mountain as a solution for nuclear waste disposal, but will begin a consent-based siting process during 2021.

9.1.2 Increased storage pool capacity.

Xcel Energy could theoretically achieve increased storage capacity by increasing the capacity of its pool storage on site through one of three means: consolidation, re-racking or a new storage pool. None of these provide a more reasonable and prudent alternative than additional dry cask storage.

9.1.2.1 Fuel Rod Consolidation

Fuel rod consolidation is a process that reduces the volume of the fuel assemblies by disassembling and repackaging the fuel rods and assembly hardware. During this process, fuel rods are removed from the fuel assembly. Then the rods are grouped in a closer-packed array and placed in a container with similar dimensions as a fuel assembly. The assembly hardware is compacted and then packed into separate containers in the pool or in a dry storage configuration. This process could be performed in an existing spent fuel pool.

This technique has not been widely used, and the domestic nuclear industry experience has been primarily limited to demonstration projects. Consequently, the technology is not as optimized or commercially mature as other alternatives. Fuel rod consolidation would require development of a site-specific solution if implemented, which could be very complex.

NSP conducted a fuel rod consolidation demonstration project at the Prairie Island Nuclear Generating Plant in 1987. The results of this project were reported in the Prairie Island Certificate of Need Case Docket No. E002/CN-91-1. Although some volume reductions for spent fuel were realized, NSP found that predicted compaction ratios for assembly hardware were not achievable. Moreover, the occupational radiation dose was significantly higher than predicted because workers were subject to increased exposure from the many time-consuming and labor-intensive fuel-handling activities. NSP also found that the consolidated assembly hardware had become activated and large portions of the assembly could not be disposed of as Class C waste, which would have reduced volume. The NSP study found that consolidation would also generate significant amounts of radioactive debris. The study estimated an additional 600 cubic meters of low-level radioactive waste containing 2500 curies would be generated from consolidation activities. Consequently, the rod consolidation alternative was rejected as an alternative to spent fuel storage at Prairie Island.

In January 2001, the DOE's Office of Civilian Management provided a Report to the US Congress entitled, *Spent Fuel Management Alternatives Available to Northern States Power Company Inc. and the Federal Government for the Prairie Island Nuclear Plant Units 1 & 2,* the report contained the following excerpt on rod consolidation at PI.

> "In the 1980's, DOE, the utility industry, and several nuclear equipment vendors developed consolidation processes and equipment; and several utilities undertook demonstration projects to test the processes and equipment. NSP demonstrated the consolidation of 36 assemblies at Prairie Island in late 1987. These demonstrations encountered numerous and varied difficulties, which were not easily resolvable. To date, no utility has pursued rod consolidation as a means of expanding onsite storage capacity for SNF."

Xcel Energy is not aware of any recent industry initiatives or design advances that would contradict the DOE's 2001 conclusion on rod consolidation. Xcel Energy is also not aware of any domestic nuclear plant owner that is seriously considering rod consolidation as a long-term solution to spent fuel storage. Xcel Energy concludes that consolidation is not a viable alternative to dry storage at the Plant.

9.1.2.2 Re-racking

Currently the Plant spent fuel storage pool is licensed to hold up to 2,237 fuel assemblies using a combination of one original low-density fuel storage rack and multiple high density fuel storage racks licensed and installed in the late 1970s. Twenty of the licensed available spaces hold used reactor control blades and eight of the licensed available spaces were plugged because those spaces did not meet the required dimensional specifications, leaving 2,209 usable spaces to store spent fuel.

Re-racking at this time would consist of replacing all of the current storage racks (one low-density fuel storage rack and all existing high-density spent fuel storage racks). Any proposal to increase the fuel storage pool capacity would be subject to review and approval by the NRC. To receive approval from the NRC the Plant would need to demonstrate that structural, thermal and nuclear limits can be safely met with the increased number of spent fuel assemblies stored in the pool.

Based on an evaluation undertaken in 2004, it was concluded that 2,651 spent fuel assemblies could potentially be licensed and safely stored in the Plant fuel storage pool were the pool re-racked. This represents an increase of 442 usable spent fuel storage spaces, which would only support plant operation for two full operating cycles of 160 new fuel assemblies and one partial fuel cycle, for a total of less than six additional years of operation. Therefore, re-racking to increase pool storage is not a viable alternative to establishing additional dry storage at the Plant to support operations until 2040.

9.1.2.3 Construct a New Pool On-site

This alternative entails constructing a new building containing a new spent fuel storage pool. The new building and pool structure would be designed and constructed to the same or higher standards as the existing spent fuel storage pool in the reactor building and would be licensed and regulated by the NRC. The new pool would be designed for older, cooler fuel.

A new storage pool would require the same components as the existing pool, which rely on active cooling rather than passive cooling systems. Pool components would include storage racks, pool cooling and filtration systems, pool bridge crane and fuel assembly handling tools, building ventilation systems, radiation monitoring equipment and a cask decontamination area. In addition, a transfer cask would be required to transfer spent fuel assemblies from the existing pool to the new pool. The number of times the spent fuel assemblies are handled would triple because, in addition to handling the fuel assemblies to place them in qualified transportation canisters, like those being proposed in this application to move the spent fuel from the pool to the

IFSI, the spent fuel assemblies would have to be handled two additional times, once to place them in the transfer casks to move to the new pool and another time to remove the assemblies from the transfer cask to be placed in the new storage pool, as there would be no way to directly transfer fuel from one pool to another. The ISFSI only requires handing fuel assemblies a single time to load them into a cask which can then be shipped offsite. It would take an estimated three years to design a new pool building and to complete state and federal reviews and approvals. Construction would last approximately two years after approval, for a total project duration of at least five years. The location would likely be similar to the existing ISFSI, i.e., directly adjacent to the reactor and turbine-generator buildings. Based on the estimates for constructing a new storage pool prepared for the Prairie Island Certificate of Need in 1991, the estimated project costs would be approximately $50 million, however this estimate is 30 years old and the actual cost to construct a new pool today would be significantly higher. This estimate does not include costs of maintaining a second active pool system nor does it include the costs associated with purchasing hardware or plant personnel to load and transport the spent fuel to Yucca Mountain when it becomes available. (loading fuel into a dry cask licensed for transportation is included in the estimate to expand the existing facility capacity) This option is not preferred due to the prohibitively high cost ..

9.1.3 Alternative Dry Cask System Technologies

Currently, there are three types of storage system technologies available for dry storage of spent nuclear fuel. All three systems rely on passive cooling to remove decay heat from the spent fuel. The three technologies vary in the manner in which they store the spent fuel, how they accommodate the transfer of spent fuel from the power plant, and how they are transported. The three types of systems are as follows:

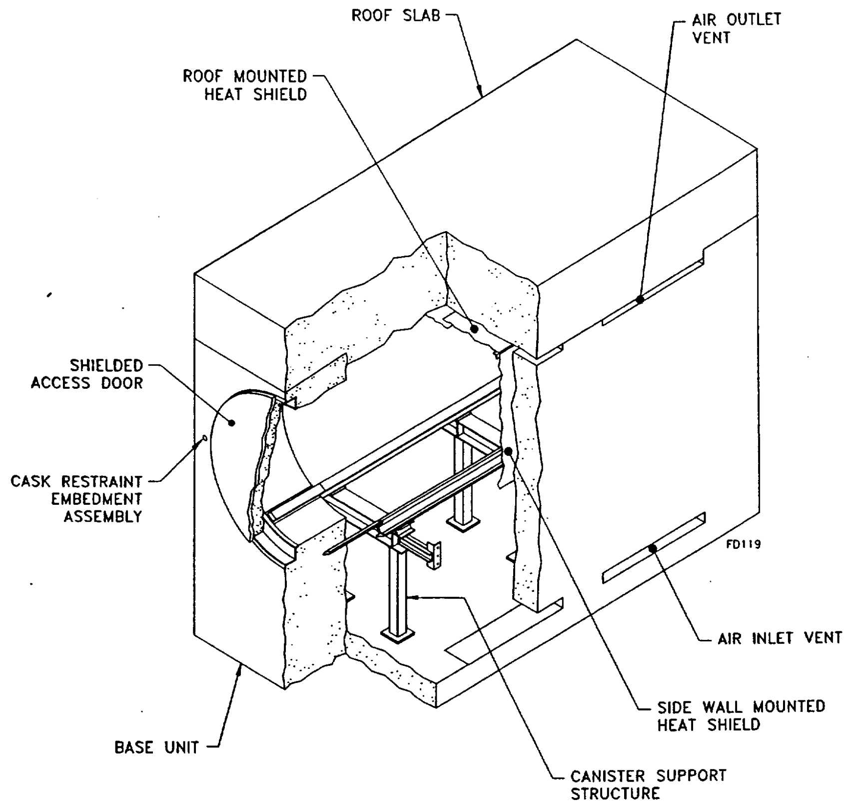
- Horizontal Canister Storage System
- Vertical Canister Storage Systems
- Non-Canister Storage Systems (Bolted Cask)

The following sections present each system and discuss their respective advantages and disadvantages. A comparison of major attributes of each system is presented in Table 9-1.

9. 1.3.1 Horizontal Canister Storage System

Horizontal canister storage is the technology currently used at the Plant. This system consists of a welded sealed metal canister to contain spent fuel assemblies and provide the primary confinement boundary, concrete storage modules that house the canisters, a transfer cask to handle the canisters, and a transportation cask to ship the canisters offsite. The storage module, transfer cask and transportation cask provide radiation shielding and physical protection, during canister transportation, transfer, or storage. The existing canisters hold 61 Monticello spent fuel assemblies.

The transfer cask is used to lift and provide radiation shielding of the canister during spent fuel loading and storage preparation activities. After the canister is loaded, it is drained, dried, inerted with helium, and welded closed. The canister is then transferred using the transfer cask, moved to the ISFSI, and loaded into the storage module for storage. The canister transfer operation occurs at the ISFSI by sliding the canister from the transfer cask into the storage module. This operation occurs in a horizontal configuration, so no overhead crane is required. The individual modules are placed on a concrete base mat next to each other to form a linear array. The modules are designed with a passive natural convection heat transfer system. The process can be reversed to transfer the canister from the storage module directly into a shipping cask. The shipping cask can be loaded onto a rail car for removal offsite.



The concrete storage modules are designed to provide passive heat transfer by natural convection from the canister through air vents built into the module. The air vents require periodic inspection to ensure they do not become blocked and a temperature monitoring system to ensure canister temperatures do not reach levels that could damage the system materials. The concrete storage module is a pre-cast reinforced concrete structure, which is fabricated offsite and shipped to the site where it can easily be placed on a concrete storage pad.

Currently, the only horizontal system available is the TN NUHOMS (Nuclear Horizontal Modular System) designed, licensed and manufactured by Orano, Inc. The system is used at several nuclear power plants throughout the United States as well as at several foreign reactors.

The advantages of using a horizontal canister storage system include:

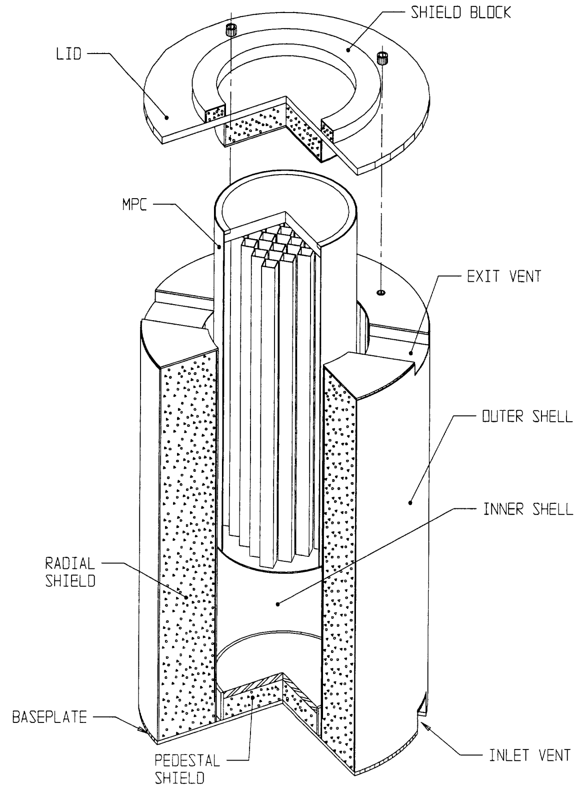
- Once welded closed, the canister never needs to be opened, which avoids having to expose or handle individual spent fuel assemblies.
- The concrete module is pre-fabricated and shipped to the site where it can easily be placed at the ISFSI.
- All canister transfers between the transfer cask and the storage module can be performed without the use of an overhead crane.
- To ship offsite, the canister needs only to be transferred from the storage module to the shipping cask without having to unload fuel in the fuel pool.
- The canister can be transferred directly from the storage module to the shipping cask at the ISFSI without having to be moved to the Plant or other structure for access to a crane.

The disadvantages of using a horizontal canister storage system include:

- The canisters have to be transferred between transfer casks, storage modules and transportation overpacks which increases the radiation doses to workers.
- The canisters require welding and weld inspection, which increases storage preparation time, which in turn increases worker doses.
- A temperature monitoring system and/or vent blockage inspection are required to ensure proper heat rejection from the canister.

9.1.3.2 Vertical Canister Storage Systems

The vertical canister storage system typically consists of a welded sealed metal canister to contain spent fuel assemblies and provide the primary confinement boundary, concrete or metal storage overpacks to house the canister, a transfer cask to handle the canister, and a transportation cask to ship the canister offsite. The storage



overpack, transfer cask and transportation cask provide radiation shielding and physical protection, during canister transportation, transfer, or storage. A typical canister will hold 56 to 68 Monticello spent fuel assemblies. The systems are licensed under 10 CFR 72 for storage and some systems are also licensed under 10 CFR 71 for transportation as well.

The transfer cask is used to lift and provide radiation shielding of the canister during spent fuel loading, and storage preparation activities. After the canister is loaded, it is drained, dried, inerted with helium, and welded closed. The canister is then transferred from the transfer cask to the storage overpack and moved out to the ISFSI for storage. The canister transfer operation typically occurs in the rail or truck bay of the Plant. However, this operation requires a supporting floor that can handle upwards of 500,000 lbs., and many plants cannot support that magnitude of load. If the floor cannot support, or be modified to support, the load, a separate canister transfer structure can be built to provide the transfer. This structure typically consists of a large crane component to lift the transfer cask on top of the storage overpack and to move the canister between the transfer cask and storage overpack. The same process is required to move the canister between the storage cask to transfer cask to a shipping cask.

The concrete storage overpacks are designed to provide passive heat transfer by natural convection from the canister through air vents built into the overpack. The air vents require periodic inspection to ensure they do not become blocked or a temperature monitoring system to ensure canister temperatures do not reach levels that could damage the system materials. Metal storage overpacks provide passive heat transfer by conduction through the overpack body. The overpacks are stored outdoors on a concrete pad. Concrete overpacks are shipped to the site as a steel frame where concrete is poured in-place to provide a radiation shield.

The advantages of using a vertical canister storage system are in large part similar to the horizontal canister systems and include:

- Once welded closed, the canister never needs to be opened, which avoids having to expose or handle individual spent fuel assemblies.
- To ship offsite, the canister needs only to be transferred from the storage cask to the shipping cask without having to unload fuel in the fuel pool.

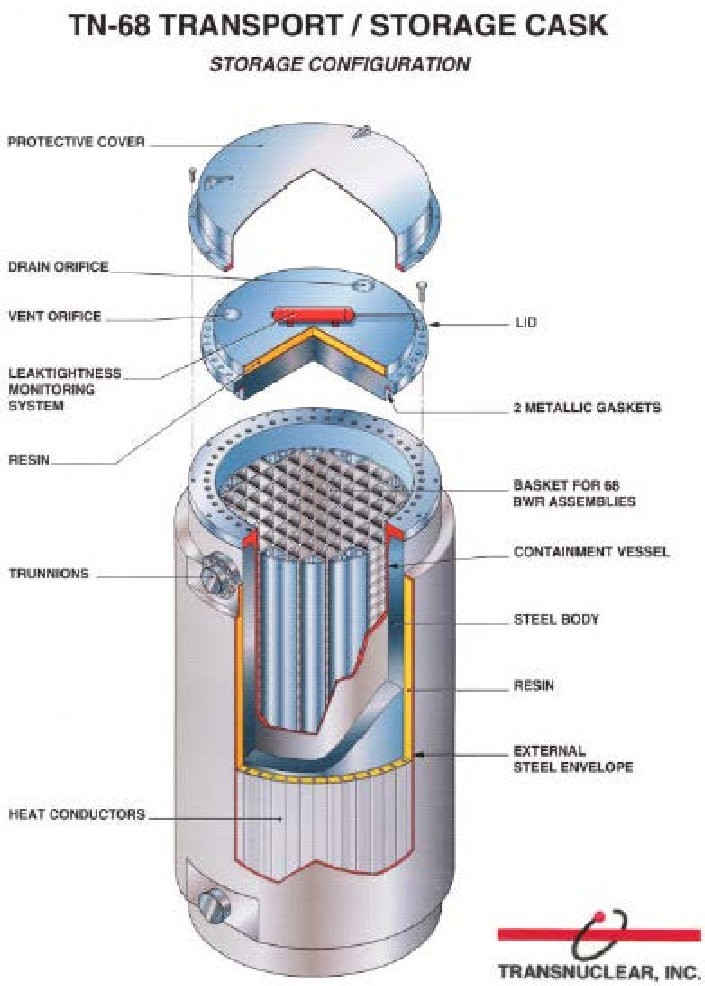
Also largely similar to horizontal canister systems, the disadvantages of using a vertical canister storage system include:

- The canisters must to be transferred between casks, which increases radiation doses to workers.

- The canisters require welding and weld inspection, which increases storage preparation time which in turn increases worker doses.
- A temperature monitoring system and/or vent blockage inspection are required to ensure proper heat rejection from the canister.
- The storage overpacks must be filled with concrete at the site requiring on-site fabrication work and a fabrication area.
- The canister transfer process requires a robust floor to support all the components or a separate structure with a robust base and overhead lifting component such as a crane

9.1.3.3 Non-Canister Storage Systems

Non-canister storage systems typically consist of a single robust metal storage component called a cask that has a lid that is bolted to the cask. The cask is licensed for storage under 10 CFR 72 and some systems are also licensed for transportation under 10 CFR 71. The cask is the primary confinement boundary. The casks are designed to store spent fuel from both Pressurized Water Reactors (e.g. Prairie Island) PWRs or BWRs (e.g. Monticello). Storage capacity is typically 68 BWR spent fuel assemblies. The spent fuel is located in an internal basket or in storage cells dispersed throughout the cask. The casks are passively cooled and may have external cooling fins to aid in heat dissipation.



The thick metal cask body provides physical protection and radiation shielding for the spent fuel. Cask bodies are either all steel or a steel and lead combination. The casks use a bolted closure consisting of a single lid with dual metallic seals. The annulus between the seals is pressurized and connected to a system that monitors the annulus for loss of pressure. The casks are stored outdoors on a concrete pad.

The loading process consists of inserting the cask into the pool, loading the spent fuel, removing the cask from the pool, bolting the lid, drying and inerting the cask with helium, and transporting the cask to the ISFSI.

Currently, the only non-canister storage system available for storage of BWR fuel is the TN-68 storage system supplied by Orano, Inc. The TN-68 is in use at the Peach Bottom nuclear plant.

The advantages of using a non-canister storage system at the Plant include:

- The cask is designed and licensed for both storage and shipping eliminating need to transfer spent fuel between different casks.
- The casks can be loaded and shipped directly offsite without having to repackage the fuel assemblies in the spent fuel pool or transfer a canister.
- No welding is required which reduces loading time and associated worker doses during the loading phase.

The disadvantages of using a non-canister storage system at the Plant include:

- The current available TN-68 cask diameter exceeds the available loading space in the Plant spent fuel pool. To use the system would require extensive modifications to move the spent fuel storage pool racks.
- The cask weight exceeds the proposed lifting capability of the Plant reactor building crane by a considerable margin.
- A pressure monitoring system is required to ensure no leakage of O-ring seals in bolted storage cask lid.

9.1.3.4 Storage System Technology Selection

A canister-based system licensed for storage and transportation, either horizontal or vertical, is recommended for the proposed expansion. A canister-based system is preferred primarily for the following reasons;

- The site has extensive experience in loading and maintaining a canister-based system
- The proposed private Central Interim Storage facilities are designed to storage canister-based systems, leading to the possibility of earlier shipment offsite.
- Canister-based systems have lower overall costs compared to other design.

There are several dry cask spent fuel storage systems currently licensed by the NRC. The specific technologies to be implemented by Xcel as part of this Project have not been selected at this time. Instead, Xcel is requesting that the MNPUC approve the additional storage necessary to support an additional 10 years of MNGP operation using a non-specific welded canister system licensed by the NRC for both storage and transportation. The specific vendor and technology would be selected closer to the date of installation using a competitive bidding process that would assess all available NRC-licensed designs.

Table 9-1 COMPARISON OF DRY CASK STORAGE SYSTEMS[1,2]

Storage System	Primary Components	Transfer Method	Closure Type	Monitor Req'mts	Storage Method	Transport Method	SFA Capacity
Horizontal Canister Storage System	Metal canister Concrete storage module Transfer cask Shipping cask	Canister Transfer	Welded canister	Temp. and/or Vent Blockage	Canister in Concrete Module	Metal Shipping Cask	61-89 BWR
Vertical Canister Storage System	Metal canister Concrete or metal storage overpack Transfer cask Transportation cask	Canister Transfer	Welded canister	Temp. and/or Vent Blockage	Canister in Concrete or Metal Overpack	Canister in Shipping Cask	68-89 BWR
Non-Canister Storage System	Storage/Transportation Cask	N/A	Bolted cask w/ O-rings	Helium Pressure	Metal Cask	Metal Cask	68 PWR

NOTES:

1. Based on existing designs that are currently licensed.
2. Not all systems may be compatible with the Monticello site. Further evaluations would be required for each particular design.

9.2 OTHER ALTERNATIVES - ALTERNATIVE SITES

Minnesota Statutes require that spent nuclear fuel storage be limited to the plant site at which the fuel is used (Minn. Stat. 116C.83 Subd. 4b). Therefore, in order to extend the operation of the Plant, additional spent nuclear fuel storage must be established on the Monticello Nuclear Generating Plant site. A detailed description of the considerations used in selecting the ISFSI site is contained in the 2005 Certificate of Need application for the original construction of the ISFSI (Docket E002/CN-05-123). As set forth in Chapter 11 of the 2005 Application, alternative sites were analyzed during that process, and the current site was selected. The reasons for selecting that site have not changed, and because the current site has sufficient space to accommodate the additional storage required to extend plant operation for 10 years beyond the 2030 date, there is no reason to consider alternative sites for the ISFSI expansion.

9.3 GENERATION ALTERNATIVES (ALSO "NO ACTION" ALTERNATIVE)

The Monticello Plant will exhaust its current nuclear waste storage capacity in 2030. Absent the additional storage provided by the Project, the Plant would need to close by that date and Xcel Energy would need to replace the substantial capacity and energy the Monticello Plant provides to the system. Therefore, in additional to analyzing alternatives for nuclear waste storage, Xcel Energy also examined alternatives that could replace the capacity and energy provided by the Plant – in essence, both a "Generation Alternatives" scenario and the "No Action Alternative" scenario.

Consideration of generation alternatives requires balancing of several factors, as set out in Minn. R. 7855.0120 (B), including:

(1) the appropriateness of the size, the type, and the timing of the proposed facility compared to those of reasonable alternatives;

> (2) the cost of the proposed facility and the cost of energy to be supplied by the proposed facility compared to the costs of reasonable alternatives and the cost of energy that would be supplied by reasonable alternatives;
> (3) the effects of the proposed facility upon the natural and socioeconomic environments compared to the effects of reasonable alternatives; and
> (4) the expected reliability of the proposed facility compared to the expected reliability of reasonable alternatives.

Since Xcel Energy's application for a CN for the ISFSI at the Monticello Plant in January of 2005, the energy generation world has changed dramatically. At that time, baseload coal and baseload natural gas were considered the primary alternatives to the Monticello Plant. Since then, renewable energy resources have become dramatically more competitive, to the point that the computer modeling used in resource planning and resource acquisition decision making no longer selects baseload coal or baseload gas as "least cost" options.

For the purposes of evaluating generation alternatives, Xcel Energy conducted modeling to examine the benefits of extending the life of the Monticello Plant in the context of our broader 2020-2034 Upper Midwest Energy Plan (Integrated Resource Plan or "IRP"). We found that extending the life of the Monticello plant is cost effective (presenting the lowest cost scenario from a present value of societal cost (PVSC) perspective, supports achievement of our carbon reduction goals, and ensures that we maintain a robust share of firm and/or dispatchable generation relative to peak load across seasons. In a case where the Monticello plant is not extended, the capacity provided by Monticello would be most cost-effectively replaced by gas combustion turbines (CTs) whereas its energy value is replaced primarily with additional wind generation. This scenario adds costs on a PVSC basis, compared to extending the life of the Plant. We subsequently conducted modeling to examine a case in which no incremental gas resources could be used to replace Monticello. In this case the model chooses to add a mix of battery energy storage, solar, and wind resources in the planning period, but it imposes additional costs relative to the Alternate Plan, on either a PVSC or present value revenue requirements (PVRR) basis. Ultimately our modeling supports extension of the Monticello plant's life, and by association, the need for additional spent fuel storage.

It is also important to note that modeling cannot capture all of the attributes of the various resources analyzed, when compared to the Monticello Plant. A complete analysis of alternatives also requires consideration of factors such as: the inherent stability and reliability of maintaining a significant baseload resource like the Monticello Plant on the Company's system; the impact of alternatives on the Company's ability to reach its goal of carbon-free generation by 2050 and the impact on the State's ability to meet its own carbon reduction goals; the diversity of resources available to meet customers' needs; the incremental risk to customers associated with greater reliance on market purchases; the land requirements and associated impacts of any new generation resources and other societal issues, including the economic benefits generated by the provision of highly skilled jobs and tax revenues to the local communities. Consideration of these factors further supports the Project and maintaining the capacity and energy provided by the Monticello Plant through 2040.

Upper Midwest Energy Plan Overview

The Company initially filed its 2020-2034 Upper Midwest IRP in July 2019 (Docket No. E002/RP-19-368). In that Plan and a subsequent Supplement in June 2020, we examined the relative benefits of 15 scenarios testing different retirement dates for the baseload resources (coal and nuclear) currently in our generation portfolio. Through the course of those two filings, we determined that "Scenario 9" – one in which our remaining coal units would be retired by 2030 and Monticello would be extended to 2040 – would be the most prudent path forward to achieving our clean energy goals while also maintaining affordability and reliability. This is true, first, because no baseload scenario that retired our nuclear units (at Monticello and Prairie Island) at their currently licensed dates achieved our goals to reduce carbon 80 percent from 2005 level by 2030 (our "80x30" goal) and, second, because, while we ultimately believe that a scenario which also extends the life of the Prairie Island units will be most cost beneficial and enable the most clean baseload generation to continue operating on our system, the Company is committed to continuing to work with the local community on their interests with respect to the plant's operation and fuel storage, and because we have additional time to determine whether pursuing a Prairie Island extension will be the most prudent path. In any case, that particular future path is only achievable if Monticello is extended, and as such, we determined pursuing baseload retirement dates consistent with baseload Scenario 9 is the most appropriate next step on our path to a carbon free future.

Since June 2020 the Company has received substantial feedback on its Plan, and in particular, the prospect of building a natural gas combined cycle (CC) facility at its Sherco site. The Company received legislative authorization in 2017 to construct, own and operate and recover the reasonable and prudent costs associated with it, to meet capacity needs emerging as the Company retired its Sherco coal units 1 and 2 ahead of their previously planned retirement dates and ensure system reliability. In our Initial and Supplement IRP filings, therefore, we included the Sherco CC in our resource plans. However, we have re-evaluated our Resource Plan to determine whether we could cost effectively meet system requirements without the inclusion of the Sherco CC.

Based on this analysis, we filed an Alternate Plan in our June 25 Reply Comments to the ongoing resource planning proceeding. The Alternate Plan maintains the proposed early coal retirements and Monticello life extension; however, it also removes the Sherco CC and reutilizes the generator interconnection rights we will have opening at the coal sites to be used for bringing on additional renewable generation, alongside limited CT and future firm dispatchable resources to provide integration support. Table 9-2 below shows the expansion plan proposed in our most recent filing.

Table 9-2:
2020-2034 Alternate Plan Expansion Plan (MW)

Type	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Total
Storage	-	-	-	-	-	-	-	-	-	-	200	50	-	-	-	250
Wind	-	-	-	-	-	-	-	-	200	200	950	350	450	-	500	2,650
Solar	-	-	-	-	700	600	-	600	150	400	100	-	-	100	500	3,150
Firm Dispatchable	-	-	-	-	-	60	259	374	-	374	374	-	374	748	374	2,937
Sherco CC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Demand Response	33	132	67	62	47	41	12	14	15	17	19	20	21	22	24	545
Energy Efficiency	115	130	116	133	143	145	154	157	155	140	138	136	129	126	126	2,041
Distributed Solar	173	72	87	68	25	16	15	15	15	15	15	15	15	15	15	575

For the purposes of the analysis provided herein, the Company has compared the Alternate Plan to two replacement cases in which Monticello is not extended, to determine whether an alternative is available that better balances cost, environmental, and risk/reliability objectives. These cases retire Monticello at its currently scheduled date and allow the resource planning model to optimize replacements needed to fill the energy and capacity needs created by the retirement. In the first case we allow the model to freely optimize the most cost-effective resources to replace Monticello. We also tested a case where we prohibit the model from choosing any incremental gas resources (over and above the firm dispatchable generation included in our IRP Alternate Plan) to backfill capacity needs left open by Monticello's retirement.

Our analysis finds that the Company's Alternative Plan best balances the core cost, environmental, and market and reliability risk objectives highlighted above. If left to optimize the most cost-effective resources to replace Monticello, the model will choose to add (or pull forward from later years) approximately 750 MW of gas-fired combustion turbines (CTs) in 2030, to meet capacity needs, alongside approximately 750 MW of additional wind resources and 200 MW of solar resources throughout the planning period, relative to the Alternate Plan. In the scenario in which we do not allow incremental CTs beyond what is selected in our Alternate Plan, effectively reflecting a "no incremental gas" scenario, the model selects resources to meet customer needs left open by Monticello's retirement entirely with solar, energy storage, and wind. Specifically, it pulls forward and/or adds an incremental 300 MW of battery energy storage resources, 600 MW of incremental solar, and 950 MW of incremental wind.

Both of these alternatives impose incremental costs – on a present value of societal cost (PVSC) basis – relative to our Alternate Plan scenario in which we operate Monticello to 2040. Based on the EnCompass resource planning model, the additional costs to replace the capacity and energy of the plant through Monticello Power Plant are likely to range from approximately $60 to 80 million on a PVSC basis. On a PVRR basis, results are more mixed. The case in which we allow CTs to replace Monticello's capacity, PVRR costs are somewhat lower than the Alternate Plan; however, in the case in which the model may not choose incremental new gas, the resulting costs on a PVRR basis continue to be higher than our Resource Plan proposal.

In addition to costs, we evaluate several other factors. We also evaluate the ability of each plan to keep us on a path toward our clean energy goals – ultimately to provide 100 percent carbon-free generation by 2050, and ensure we are mitigating customer risk and system reliability issues. With respect to these factors, and in combination with cost considerations, the Company's proposed plan provides the best balance of meeting these objectives. Our Alternate Plan achieves 86 percent carbon reduction from 2005 levels by 2030-2031 and maintains a high level of carbon reduction throughout the planning period, whereas the fully optimized replacement case does not achieve the same carbon reduction and does not advance us as far down the path to our 2050 goals. The extension of Monticello also helps us maintain a healthy ratio of firm and dispatchable capacity to peak demand – across seasons and throughout the planning period while achieving high levels of carbon reduction; conversely, cases that do not include Monticello extension rely on either incremental gas (or as-yet to be developed) resources to provide firm capacity or on variable or use-limited resources, which are not always available like the clean baseload energy Monticello provides. We also find that both replacement cases rely more on market purchases to meet customer needs than the Alternate Plan, and in the case where Monticello is replaced primarily by CTs and wind, net market sales decline significantly. This reduction of cost-effective baseload generation combined with increased market reliance to serve customer needs is a risk consideration, especially during times of unexpectedly high net load.

A summary of our analysis results is shown in Table 9-3, with the best result highlighted in each category. The results of each replacement case are also discussed in more depth below.

Table 9-3:
Summary Findings for Monticello Replacement Cases, as Compared to the Alternate Plan

Category	Measure	Alternate Plan *(as presented in IRP)*	Monticello Replacement 1 *(fully optimized replacement)*	Monticello Replacement 2 *(replace with only renewables and storage)*
Resource assumptions and selection	Baseload retirements assumed before 2034	• King (2028) • Sherco 3 (2030) • Prairie Island (2033-2034)	• King (2028) • Sherco 3 (2030) • Monticello (2030) • Prairie Island (2033-2034)	• King (2028) • Sherco 3 (2030) • Monticello (2030) • Prairie Island (2033-2034)
	Resources optimized	All available	All available	• Wind, solar, battery energy storage • Must replace all energy and capacity from Monticello by 2031

	Incremental resources (MW) selected to replace Monticello capacity and energy relative to the Alternate Plan, through 2034	n/a	• CT: 750 • Wind: 750 • Solar: 200 *Plus fewer market sales and additional market purchases*	• Storage: 300 • Solar: 700 • Wind: 950 *Plus additional market purchases*
Cost[2]	2020-2045 PVSC ($ million) delta from Alternate Plan *Delta from Alternate Plan*	n/a	63	77
	2020-2045 PVRR ($ million) delta from Alternate Plan	n/a	(38)	77
Environmental Performance	Carbon reduction from 2005 levels, 2031 (percent)	86	83	86
	Total carbon serving customers, 2031 (million tons)	3.815	4.721	3.840
	Total carbon-free generation, 2031 (percent)	82	78	82
Risk and Reliability	Firm capacity-to-annual (summer) peak demand ratio, 2034	0.58	0.58	0.51
	Firm capacity-to-winter peak demand ratio, 2034	0.80	0.80	0.71

Monticello Replacement Case 1: Optimizing Monticello Replacement

In the first replacement case we tested, we replicate all the parameters of the Alternate Plan, except that we retire Monticello according to its currently planned end of license in 2030. When Monticello is removed from the resource portfolio, the EnCompass model must select new resources to meet the outstanding system capacity need (made

[2] Deltas may not tie out to total PVSC and PVRR values noted here due to rounding.

up of our forecasted load plus MISO-required planning reserve margin) we would have in the absence of Monticello. The model also optimizes to meet energy needs – either with resource additions or market purchases – that we would have on our system but for Monticello's operation. This analysis is consistent with our "baseload Scenario 4" from our IRP analyses, including the coal interconnection reutilization proposal discussed in our IRP Reply Comments.

Nuclear resources – as baseload units – have a unique benefit in that they provide substantial capacity and energy all in one generating facility. Replacement Case 1 shows us that – if left to optimize freely – the model will choose approximately 750 MW of incremental CT capacity (above what is chosen in the Alternate Plan) to replace the *capacity value* left by Monticello's retirement. The model adds this additional capacity in 2030, essentially to directly replace Monticello. The direct replacement of Monticello's capacity by firm dispatchable resources in 2030 ensures that this Case maintains effectively the same firm resource-to-peak load ratio as the Alternate Plan. Therefore, from a capacity hedging perspective (as indicated in the "firm-to-peak ratio" metrics described above, we do not expect this case would result in significant incremental risk to customers on that basis. That said, eliminating nuclear energy from our system does reduce resource diversity, which is also an important risk element to consider; in the absence of coal generation after 2030, nuclear is our only remaining baseload generation available, and certainly the only zero carbon baseload generation available to our system. Retiring Monticello (especially if Prairie Island is also not eventually extended) would eliminate a key building block of our system, leaving it to rely heavily on peaking dispatchable resources, variable renewables, and duration/use limited resources (such as battery energy storage or demand response), thereby increasing the system's exposure to risks associated with the operational attributes of each of these resources. Maintaining fuel and attribute diversity with clean baseload generation also provides significant risk mitigation value as we work to carefully manage the energy transition.

When we further examine the expansion plan from this replacement case, we see that it also adds resources to partially replace the *energy* value no longer provided by the

Monticello unit. To do this, the model chooses incremental wind, mostly across the 2030-2034 timeframe; wind resources do not provide substantial capacity value to our system but are a valuable energy resource in the model. We noted that the model results also included 200 MW of incremental solar resources during this timeframe, relative to the Alternate Plan, and it also relies more heavily on market purchases. As we note below, the full amount of energy generated by Monticello is not replaced in this case, rather the model instead opts to fill any additional customer needs with incremental market purchases.

Table 9-4:
2020-2034 Replacement Case 1 Capacity Expansion Plan

Type	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Total
Storage	-	-	-	-	-	-	-	-	-	-	200	-	-	-	50	**250**
Wind	-	-	-	-	-	-	-	-	250	250	1,000	550	100	200	1,050	**3,400**
Solar	-	-	-	-	700	700	-	550	50	450	100	-	-	400	400	**3,350**
Firm Dispatch-able	-	-	-	-	-	60	259	374	-	374	1,122	-	374	748	374	**3,685**
Sherco CC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Demand Response	33	132	67	62	47	41	12	14	15	17	19	20	21	22	24	**545**
Energy Efficiency	115	130	116	133	143	145	154	157	155	140	138	136	129	126	126	**2,041**
Distribute d Solar	173	72	87	68	25	16	15	15	15	15	15	15	15	15	15	**575**

When examining the difference in energy mix between the two cases, we see that the clean baseload energy that would have been produced by the Monticello plant is only partially backfilled with a mix of renewables and gas generation. The Replacement Case requires additional gas dispatch from existing resources (such as gas CCs) and new and existing CTs. Further Replacement Case 1 includes substantially less generation overall than the Alternate Plan, indicating that the resultant resource portfolio includes reduced sales and increased market purchases rather than fully replacing the generation from Monticello. This creates an exposure point for customers; if we have to lean more heavily on the market to meet customer energy needs, customers are more exposed to electricity market price volatility, whereas nuclear energy provides steady, low cost and carbon-free energy on a 24/7 basis (planned outages notwithstanding). Market energy is also more carbon intensive than our own resource mix, which puts upward pressure on carbon emissions, as further discussed below).

Table 9-5 below shows the difference in generation by fuel type between the Alternate Plan and Replacement Case 1, for the years in which Monticello is proposed to be extended.

Table 9-5:
2030-2040 Difference in Energy Mix Between IRP Alternate Plan and Replacement Case 1, by Fuel Type (Gigawatt Hours)

Fuel Type	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Combined Cycle	108	837	1,352	538	114	202	198	145	196	267	118
Combustion Turbine	295	520	572	386	250	414	335	375	314	216	374
Nuclear	(1,682)	(4,918)	(5,388)	(4,918)	(5,373)	(4,918)	(5,388)	(4,918)	(5,373)	(4,918)	(3,706)
Solar PV	(37)	62	189	590	435	396	512	455	513	499	486
Wind	618	1,404	367	951	3,267	2,420	2,869	2,820	2,859	2,835	981
Total[3] generation difference	**(698)**	**(2,094)**	**(2,907)**	**(2,454)**	**(1,308)**	**(1,486)**	**(1,474)**	**(1,123)**	**(1,491)**	**(1,100)**	**(1,746)**
Market purchases	*286*	*640*	*811*	*939*	*622*	*733*	*730*	*594*	*720*	*673*	*687*
Market sales	*(411)*	*(1,428)*	*(2,059)*	*(1,496)*	*(684)*	*(752)*	*(741)*	*(530)*	*(768)*	*(464)*	*(960)*

Note: this table shows total generation from Replacement Case 1, minus the Alternate Plan, to show the differences between the two cases. Negative numbers means that there is less of a type of generation or market interaction in Replacement Case 1 than in the Alternate Plan.

From a cost perspective, this Replacement Case results in higher costs on a PVSC basis, of approximately $63 million over the full analysis period (2020-2045). There are several contributing factors to these cost differences between the cases. First, while Replacement Case 1 results in reduced cost associated with running the Monticello facility for an additional 10 years, these reductions are largely offset by the incremental CT, wind, and solar resources selected in the plan. Further, the Replacement Case results in higher market purchase costs and less revenue from market sales. Finally, there are higher levels of generation from emitting resources and

[3] Note: some fuel types with zero or *de minimis* differences in generation between the cases have been removed from the table.

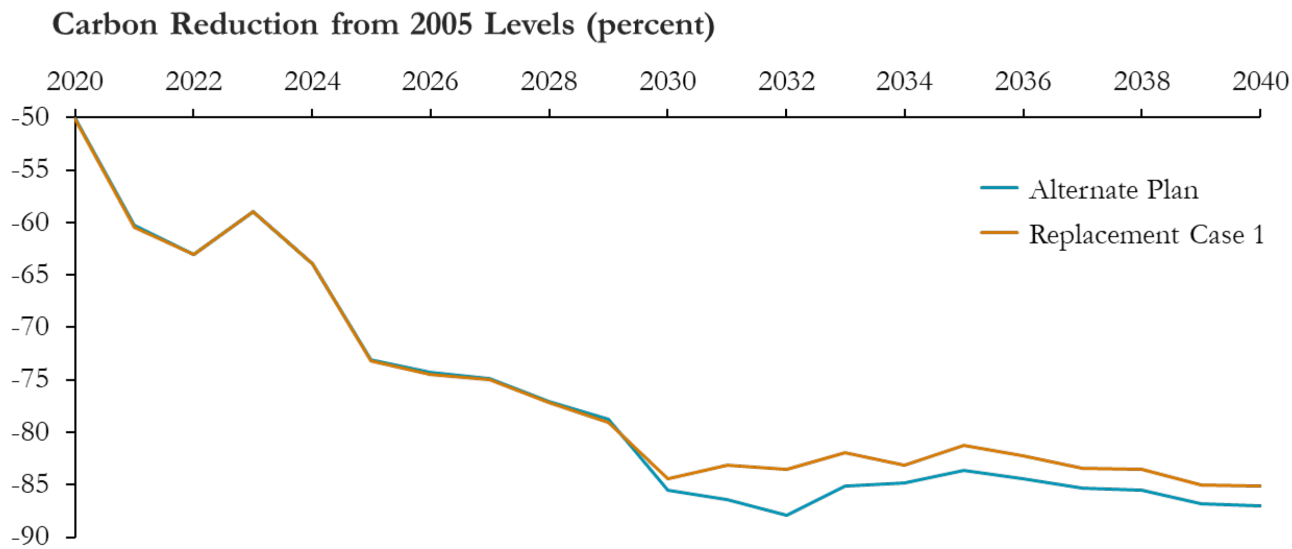
market purchases, which all increase emissions associated with the plan and thereby the cost of carbon. On a PVRR basis, because a cost of carbon is not included and there are differences in resource dispatch, this plan results in incremental savings relative to the Alternate Plan, of approximately $38 million. Minnesota planning standards, however, require consideration of externality costs and regulatory cost of carbon for emitting resources.[4] Considering only the PVRR costs of each scenario would risk customer exposure to future federal or state policy changes that prioritize or require increasingly clean energy supply.

As mentioned above, examining the carbon emissions in this Replacement Case relative to the Alternate Plan in our IRP shows that removing the Monticello unit from our portfolio and allowing the model to optimize its replacement with gas and wind resources leads to increased carbon emissions associated with serving customers. As shown in Figure 9-1 below, Replacement Case 1 achieves lower levels of carbon reduction from a 2005 baseline after 2030, and notably regresses from its 2030 low when Monticello retires. This regression occurs because, although a number of renewable resources are added to partially replace the energy from Monticello, the system also relies more heavily on gas generation and market purchases to serve customer needs when renewables are not available. Therefore, when the Monticello plant is retired in 2030, the emissions reduction achievement of Replacement Case 1 diverges from the Alternate Plan and does not achieve the same level of carbon reduction throughout the proposed duration of the Monticello extension. As noted in the summary table above, the Monticello Replacement 1 case includes nearly one million tons of additional carbon emitted in service of customer needs in 2031, the first year after Monticello would cease operations.[5] It does not recover to achieve better levels of carbon reduction until later in the 2030s.

[4] Minn Stat 216B.2422 subd.3.

[5] Carbon serving customers is represented as the emissions of carbon from our generation, adjusted for purchases and sales.

Figure 9-1:
Carbon Reduction from 2005 Levels, through 2040



<u>Monticello Replacement Case 2: Renewable and Storage Only Replacement</u>

In the second Replacement Case we evaluate an expansion plan in which we do not allow the model to choose new CT resources to fulfill the capacity need left in the plan when Monticello is retired. Instead, we force the model to replace the total amount of capacity and energy from Monticello by 2031 from other resources; namely wind, solar and battery energy storage. These constraints are intended to help us examine a case in Monticello is fully replaced, only by resources without point source emissions.[6]

The result of this constraint is that the model adds more battery energy storage, solar and wind resources throughout the planning period, relative to the Company's

[6] We do note, however, that our Alternate Plan adds firm dispatchable resources (modeled as CTs) beyond 2030, and thus to isolate the impact of Monticello's retirement specifically, we constraint the model from adding any incremental gas and/or firm dispatchable resources over and above what is already included in the Alternate Plan's expansion plan. Resources without point source emissions refers to the fact that energy storage charged off system energy may have emissions associated with discharge, but those emissions are experienced at the source of original generation rather than from discharging the battery.

Alternate Plan. Some of these resource additions are pulled forward to the years before Monticello retires – in essence to prepare for Monticello's retirement – and some are added in 2030 and after. Table 9-6 below shows the yearly additions indicated in our modeling for Replacement Case 2. In total, this case includes an additional 300 MW of energy storage, 950 MW of wind, and 700 MW of solar throughout the planning period (to 2034); however, these additions are largely pulled forward from later analysis years outside the planning period in the Alternate Plan. In other words, in the out years beyond our planning period, the Alternate Plan also adds renewables and storage, but in Replacement Case 2 the model is forced to choose them in earlier years to make up for Monticello's retirement. It is also interesting to note that - because Monticello is both a capacity and energy resource, whereas other types of resources often only provide primarily energy or capacity – the model must replace these attributes with a variety of different technologies rather than only one type. Replacement capacity attributes are provided primarily by a combination of storage and solar resources, and replacement energy attributes are provided by a combination of solar and wind resources.

Table 9-6:
2020-2034 Replacement Case 2 Capacity Expansion Plan

Fuel Type	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Total
Storage	-	-	-	-	-	-	-	-	-	-	500	-	-	-	50	550
Wind	-	-	-	-	-	-	-	-	250	250	1,200	900	400	-	600	3,600
Solar	-	-	-	-	750	550	-	600	150	400	550	350	-	200	300	3,850
Firm Dispatch-able	-	-	-	-	-	60	259	374	-	374	374	-	374	748	374	2,937
Sherco CC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Demand Response	33	132	67	62	47	41	12	14	15	17	19	20	21	22	24	545
Energy Efficiency	115	130	116	133	143	145	154	157	155	140	138	136	129	126	126	2,041
Distribute d Solar	173	72	87	68	25	16	15	15	15	15	15	15	15	15	15	575

When examining the difference in energy mix between the two cases, we see that the clean baseload energy that would have been produced by the Monticello plant is largely backfilled with renewable generation.[7] That said, in this Replacement Case we still observe incremental market purchases, indicating that this plan leans more on the market than our Alternate Plan in the IRP even though, on an annual basis, all the energy from Monticello is being replaced. This occurs because, whereas Monticello provides "always on," non-emitting baseload generation, renewables are variable and may not be producing energy at the times the system needs it to serve customers and needs to be balanced with increased market purchases. While this creates less market exposure than the unconstrained case, it still requires that we depend more on the market to serve customer needs in this case than in the Alternate Plan that includes Monticello extension.

Table 9-7 below shows the difference in generation by fuel type between the Alternate Plan and Replacement Case 2, for the years in which Monticello is proposed to be extended.

Table 9-7:
2030-2040 Difference in Energy Mix Between IRP Alternate Plan and Replacement Case 2, by Fuel Type (Gigawatt Hours)

Generator Type	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Combined Cycle	(220)	(238)	18	(330)	(150)	53	(147)	(269)	(48)	85	(129)
Combustion Turbine	(174)	(82)	(76)	(113)	(115)	(38)	(65)	(41)	(46)	103	204
Nuclear	(1,682)	(4,918)	(5,388)	(4,918)	(5,373)	(4,918)	(5,388)	(4,918)	(5,373)	(4,918)	(3,706)
Solar PV	691	1,318	1,341	1,496	1,234	1,247	1,242	1,250	1,314	882	874
Wind	1,332	3,779	3,722	3,610	4,058	2,804	4,094	3,600	3,645	3,177	1,317
Total Generation Difference	**(52)**	**(141)**	**(383)**	**(255)**	**(345)**	**(852)**	**(264)**	**(375)**	**(507)**	**(671)**	**(1,439)**
Market purchases	***243***	***270***	***349***	***399***	***454***	***673***	***474***	***539***	***566***	***569***	***619***
Market sales	***86***	***35***	***(120)***	***65***	***20***	***(253)***	***127***	***71***	***(21)***	***(161)***	***(744)***

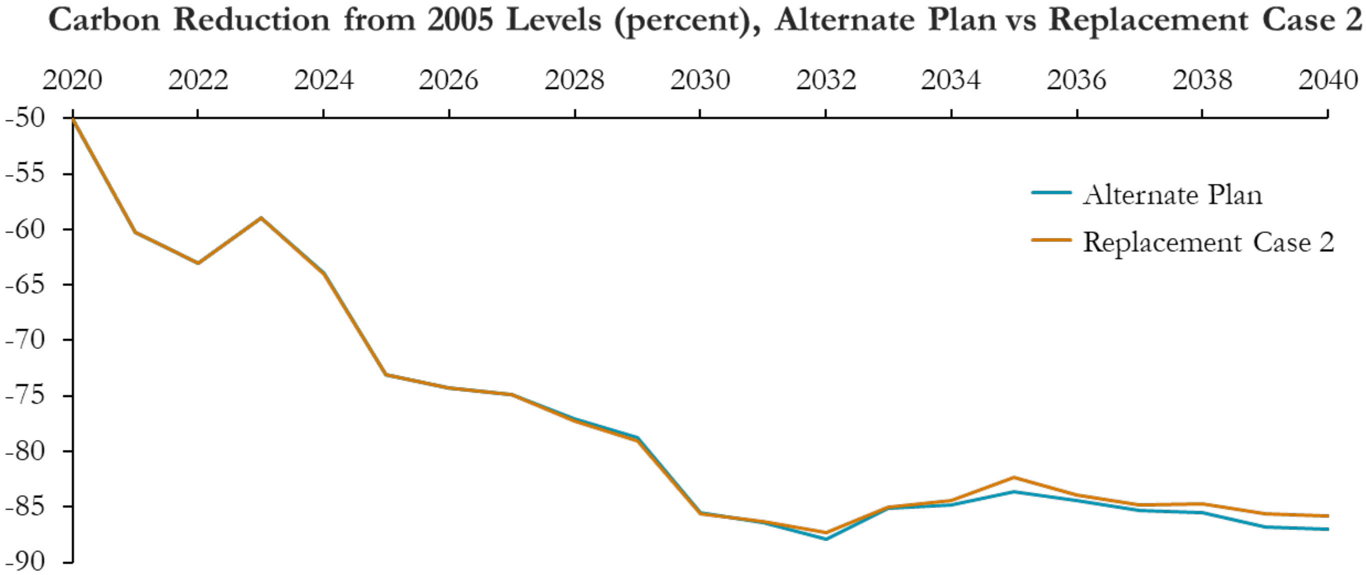
[7] Note that energy discharges from storage are not included here because these are assumed to be charged with energy from native resources or the market; thus, including storage as a separate line item here would be double counting some energy.

From a cost perspective, this Replacement Case results in higher costs on both a PVSC and PVRR basis by approximately $77 million over the full analysis period (2020-2045). There are several contributing factors to these cost differences between the cases. Again here, while Replacement Case 2 results in reduced cost associated with running the Monticello facility for an additional 10 years, these reductions are offset by the storage, wind, and solar resources pulled forward into earlier years. Further, while there is relatively little difference in annual market sales between Replacement Case 2 and the Alternate Plan, this case relies more heavily on market purchases. Also underlying this cost result is increased integration costs[8] associated with higher levels of wind and solar added here, in earlier years, relative to the Alternate Plan.

On a carbon emissions basis, this Replacement Case performs better than one in which incremental CTs are allowed and similarly to the Alternate Plan; this is because we required the model to choose resources to replace the energy from Monticello with zero emissions renewable resources. However, there are still differences in the emissions reduction achievement between cases, due largely to increased market purchases in Replacement Case 2.

[8] Integration costs account for the cost of market uncertainty around renewable energy production forecasts; essentially that the market needs to carry additional resources in order to make up for probabilistic uncertainty in that forecasting.

Figure 9-2:
Carbon Reduction from 2005 Levels, through 2040



Finally, it is worth noting here that this plan does not maintain the same level of firm and dispatchable capacity on our system as the Alternate Plan or Replacement Case 1. This ratio is an indication of how much market risk a particular portfolio may result in during periods of low renewable and/or duration limited resource availability. Whereas the Alternate Plan and Replacement Case 1 maintained a nearly 60% ratio relative to summer peak demand and an 80% ratio relative to winter peak demand, Replacement Case 2 relies more heavily on variable renewables and duration limited energy storage. This plan results in a firm-to-peak load ratio of closer to 50% in the summer and 70% for winter load. We recognize that a ratio of firm and dispatchable generation to peak seasonal demand is not a MISO-approved reliability metric; however, we do believe it is a helpful indicator of potential market risk, especially in light of observed periods of low renewable output over multi-day events, such as Winter Storm Uri or the 2019 polar vortex. During this period of time, our nuclear units were valuable and stable sources of clean baseload generation whereas wind resources were lower than average across much of the Company's Upper Midwest footprint.

CHAPTER 10. HISTORICAL AND FORECAST DATA (MINN. R. 7855.0620)

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. 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;
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;
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;
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;
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;
F. a discussion of the methodology, statistical techniques, and data bases used in providing the forecast data required by items C and E; and
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.

The following information responds to Minn. R. 7855.0620, which requires five years of historical data and forecast of demand on a nuclear spent-fuel storage or disposal facility. While the rule appears to contemplate the development of spent-fuel storage facilities that would accept spent fuel from nuclear facilities anywhere in the United States, Minnesota law restricts on-site storage at Minnesota's nuclear generating plants to spent fuel generated at that facility. Minn. Stat. § 116C.83, subd. 4(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.") Consequently, the information provided to address section 7855.0620 is limited to information relevant to the spent fuel generated at the Monticello Plant.

10.1 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.

As noted above, no material other than that generated at the Monticello Plant can be stored in the proposed facility. Table 1 contains the number of spent fuel assemblies that were discharged at the Plant from 2015 to 2020 and the equivalent metric tons of uranium and volume of those assemblies. Data for the Plant assumes that all assemblies contain 0.173 metric tons of uranium (MTU). A Monticello Plant spent fuel assembly volume is 0.078 cubic meters (172 inches long with a 5.28-inch square cross section).

TABLE 1 RESPONSE TO 7855.0620 – ITEM A	
HISTORICAL ANNUAL SPENT FUEL DISCHARGES AT MONTICELLO	
Year	**NUMBER OF ASSEMBLIES**
2016	0
2017	148
2018	0
2019	168
2020	0
2021	160
Year	**EQUIVALENT METRIC TONS OF URANIUM**
2016	0
2017	25.6
2018	0
2019	29.1
2020	0
2021	27.68
Notes: Assumes approximately 0.173 MTU per assembly at Monticello	
Year	**EQUIVALENT CUBIC METERS OF SPENT FUEL**
2016	0
2017	11.63
2018	0
2019	13.20
2020	0
2021	12.57
Notes: Assumes a Monticello fuel assembly 172 inches long, with a 5.28-inch square cross section.	

10.2 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.

This data is contained in the following Table 2. Conversion factors for calculating cubic meters of spent fuel are the same as those used in responding to subpart A of this Rule. The values reflect the useable storage space in the spent fuel pool. The values reflect two considerations

1. 484 spaces in the spent fuel pool are reserved for a full core offload at the end of life and are therefore not considered available for spent fuel storage.
2. The increase in capacity reflected in 2018 result from loading 14 dry casks that removed 854 spent fuel assemblies from the spent fuel pool.

TABLE 2 RESPONSE TO 7855.0620 – ITEM B	
HISTORICAL YEAR-END REMAINING STORAGE CAPACITY IN THE MONTICELLO SPENT FUEL POOL	
YEAR	**NUMBER OF ASSEMBLIES**
2016	779
2017	631
2018	1,485
2019	1,317
2020	1,317
2021	1,157
YEAR	**EQUIVALENT METRIC TONS OF URANIUM**
2016	134.8
2017	109.2
2018	256.9
2019	227.8
2020	227.8
2021	200.12
YEAR	**CUBIC METERS**
2016	61.2
2017	49.6
2018	116.7
2019	103.5
2020	103.5
2021	90.92

10.3 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.

As noted above, no material other than that generated at the Monticello Plant can be stored in the proposed facility. Therefore, Table 3 contains only the estimated number of spent fuel assemblies to be discharged at the Plant from 2021 to 2030 and the equivalent metric tons of uranium and volume of those assemblies. The 2029 discharge would be smaller to allow approximately one full year of power operation until shutdown in 2030. At permanent shutdown in 2030, the full reactor core of 484 assemblies would be discharged. Data for the amount to be generated in the event the Plant runs an additional ten years is provided in Table 8-1.

TABLE 3 RESPONSE TO 7855.0620 – ITEM C			
PROJECTED ANNUAL SPENT FUEL DISCHARGES AT MONTICELLO			
YEAR	**NUMBER OF ASSEMBLIES**	**MTU**	**VOLUME**
2023	160	27.68	12.6
2025	160	27.68	12.6
2027	160	27.68	12.6
2029	120	20.76	9.43
2030	484	83.73	38.0

10.4 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.

This data is provided in Table 4. Known storage facilities to be added in the United States during the forecast years that could accept spent fuel generated at the Monticello Plant include the planned DOE repository facility at Yucca Mountain as well as three private initiatives to provide centralized interim storage. On-site facilities at existing reactors are not included as they are not licensed to store fuel from the

Plant. The beginning operation dates for the DOE storage facilities are uncertain at this time as is the DOE acceptance rate for spent fuel.

While the Private Fuel Storage Facility proposed to be located at Skull Valley, Utah, is included for completeness, there are currently no efforts to construct or operate this facility. The two central interim storage facility applications – the WCS and HI-STORE facilities are the only projects moving forward at this time.

TABLE 4 RESPONSE TO 7855.0620 – ITEM D
PLANNED CENTRALIZED PRIVATE OR DEPARTMENT OF ENERGY FACILITIES FOR SPENT FUEL 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.
Private Fuel Storage, LLC Licensee: Private Fuel Storage, LLC Location: Skull Valley, Utah Capacity: 40,000 MTU In-service date: Project not being actively pursued at this time.
WCS CISF License Applicant: Interim Storage Partners, LLC Location: Andrews County, Texas Capacity: 5,000 MTU (Phase 1) In-service date: NRC license expected 2021
HI-STORE CIS License Applicant: Holtec International Location: Lea County, New Mexico Capacity: 8,680 MTU (Phase 1) In-service date: NRC license expected early 2022

10.5 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.

The additional storage would be loaded in a continuous campaign scheduled for 2028. A continuous loading campaign has several advantages, including reduced cost by a single mobilization/demobilization of the specialized crews required and reduced impact on plant operations. As such, the 25, 50, and 100% capacity milestones would all be reached during the 2028 loading campaign.

10.6 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 required by items C and E were obtained from the nuclear fuel management plans for the Monticello Plant, specifically the timing and size of each planned refueling. Spent fuel discharges are a direct function of the number of new assemblies inserted into the core during each refueling outage. This number can vary slightly based on factors such as desired cycle length, outage length and timing, fuel design changes, and replacement power costs.

10.7 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.

The major assumption is the expected number of new assemblies inserted into the core during each refueling. As noted in the response to 7855.0620 (F), slight variations in the number of discharged assemblies is possible due to changes. The total variation over 10 years of operation would be expected to be small, in the 5-10% range. Another assumption in the forecast is that the Plant will continue to operate beyond the existing license expiration date of 2030. If not, then decommissioning would commence and all fuel in the reactor as well as the fuel remaining in the spent fuel pool would be transferred to dry storage as part of the decommissioning process.

The responses to sections A to E also assume sufficient reserve capacity is retained in the Plant's spent fuel pool for a full core discharge of fuel. Finally, due to the uncertainties associated with the time to license, construct and begin accepting fuel at both Yucca Mountain and the two proposed private centralized interim storage facilities, it has been assumed that in order to ensure that the Plant is available to serve Minnesota ratepayers until September 2040, sufficient dry cask storage capacity needs to be put in place to meet the needs for the entire operating period.